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The Dock & Harbour Authority

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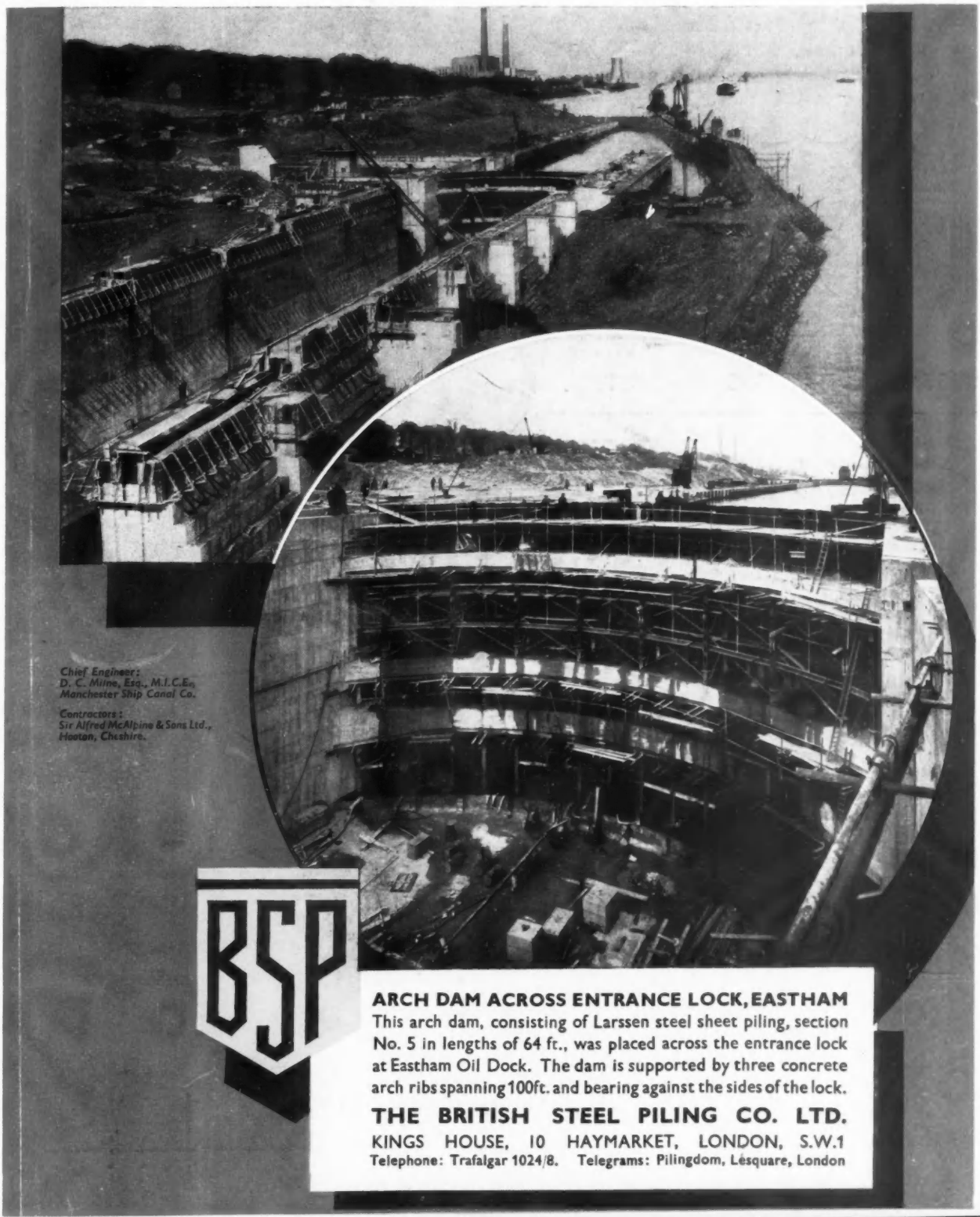
No. 393. Vol. XXXIV. JULY, 1953 Monthly 2s. 0d.



ARCH DAM ACROSS ENTRANCE LOCK, EASTHAM

This arch dam, consisting of Larssen steel sheet piling, section No. 5 in lengths of 64 ft., was placed across the entrance lock at Eastham Oil Dock. The dam is supported by three concrete arch ribs spanning 100ft. and bearing against the sides of the lock.

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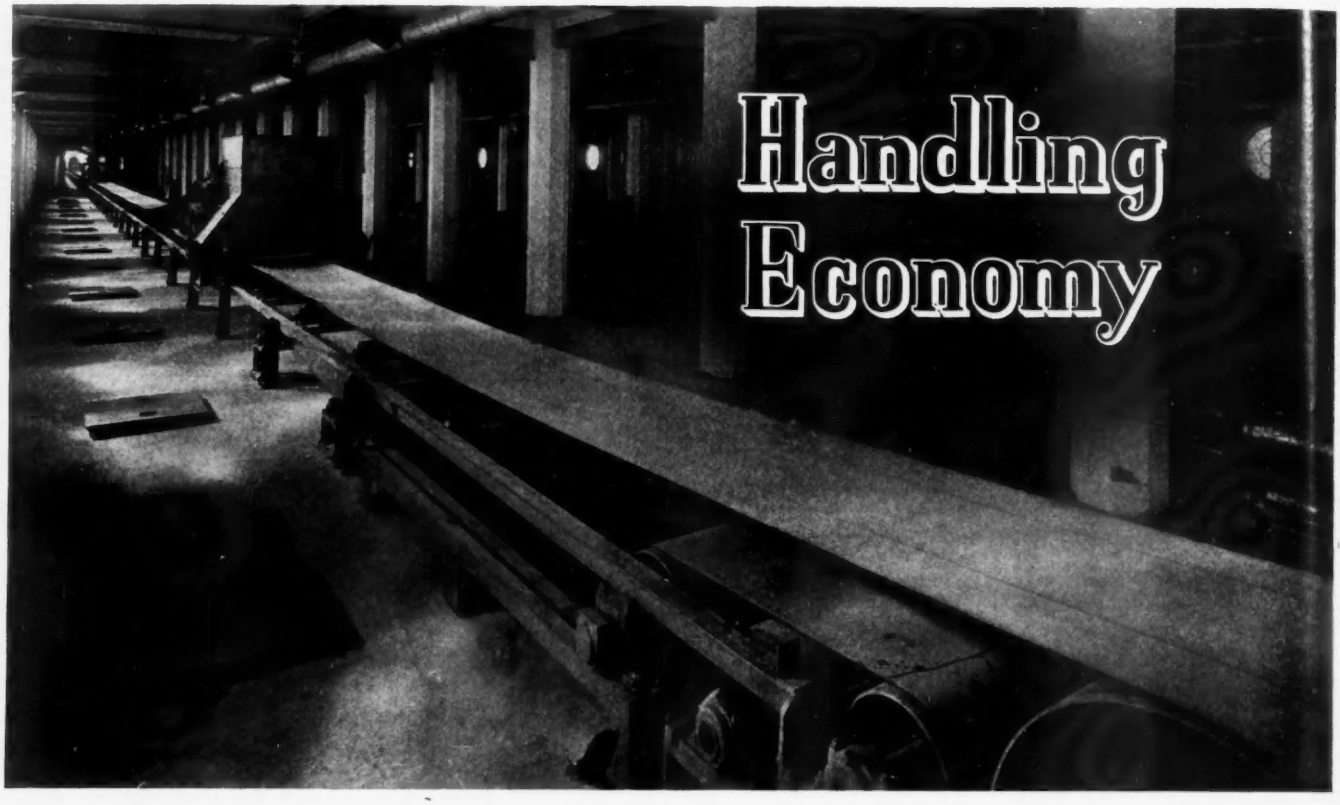

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Handling Plant

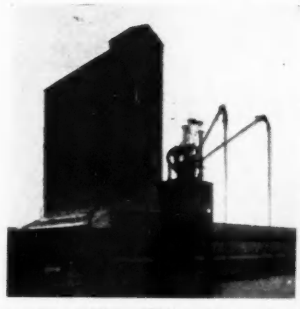
Above—Troughed Belt Conveyors with travelling throw-offs delivering grain to storage bins.

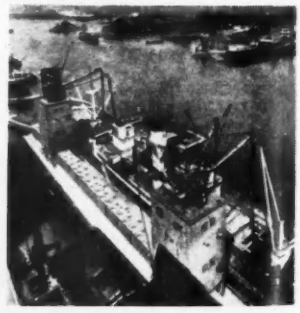
Bottom left—Floating Pneumatic Plant at Liverpool, transferring grain from ocean-going ships to barges at the rate of 250 tons per hour.

Top left—3,000 Ton grain Silo and 100 tons per hour Travelling Pneumatic Intake Plant at Preston.

Top right—One of two Travelling Pneumatic Grain Intake Elevators, each handling 120 tons per hour at Solent Mills, Southampton.

Bottom right—400 Tons of grain per hour is handled by these two Travelling Pneumatic Intake Plants at Victoria Dock, London.





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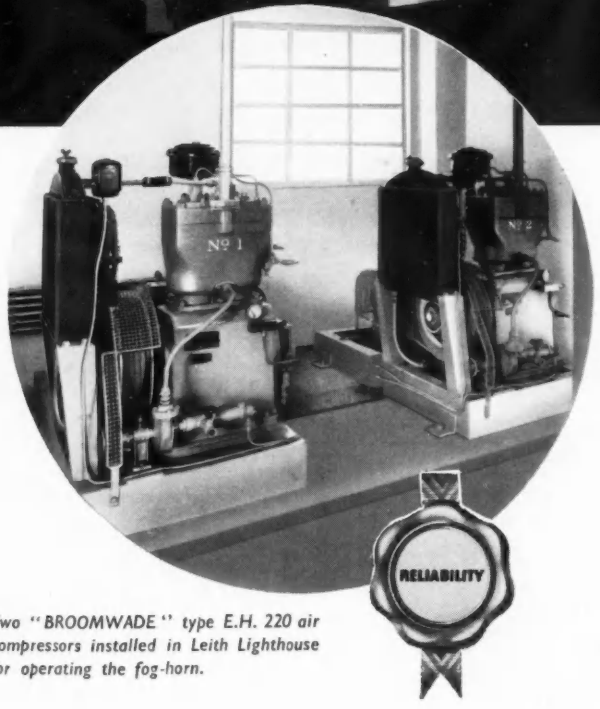

Two "BROOMWADE" type E.H. 220 air compressors installed in Leith Lighthouse for operating the fog-horn.

Photograph by courtesy of British Thomson-Houston Co. Ltd., and Leith Dock Commission.

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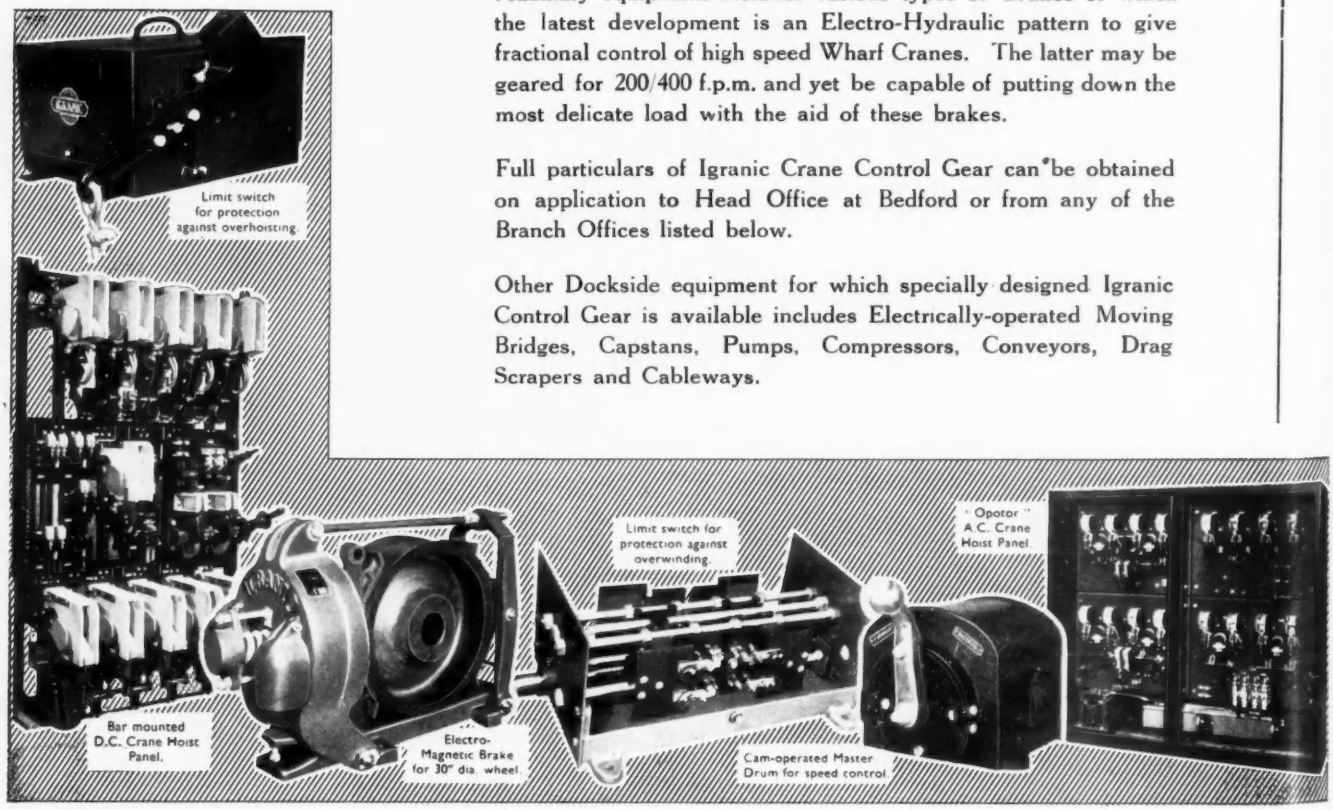
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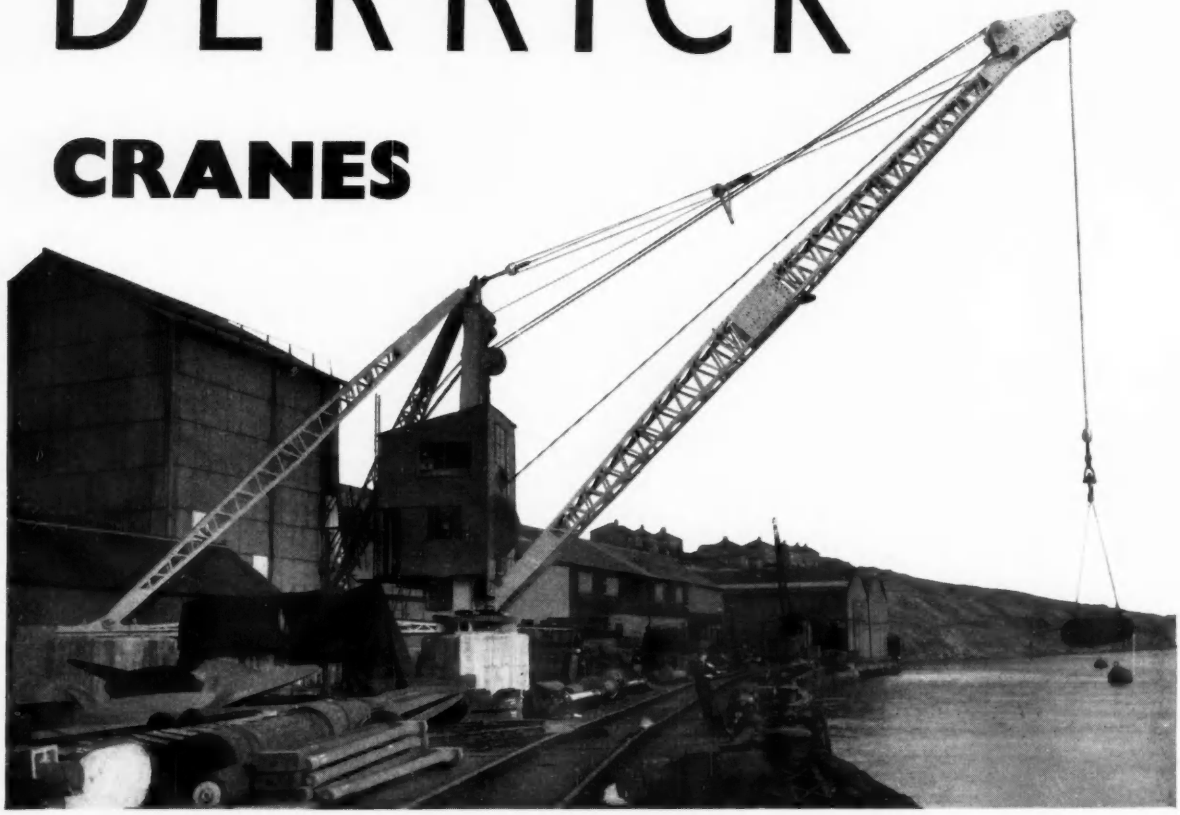

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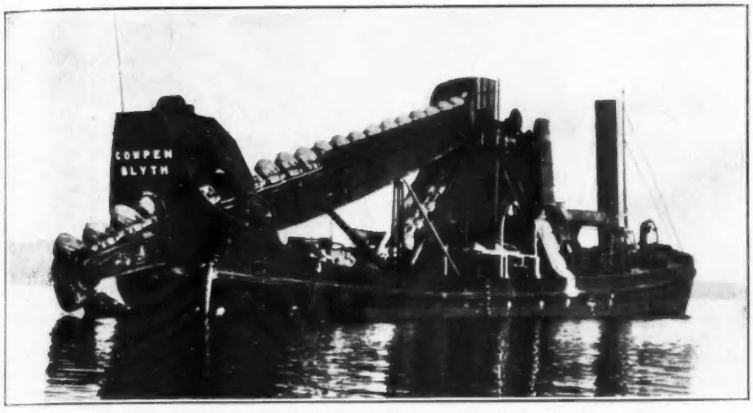

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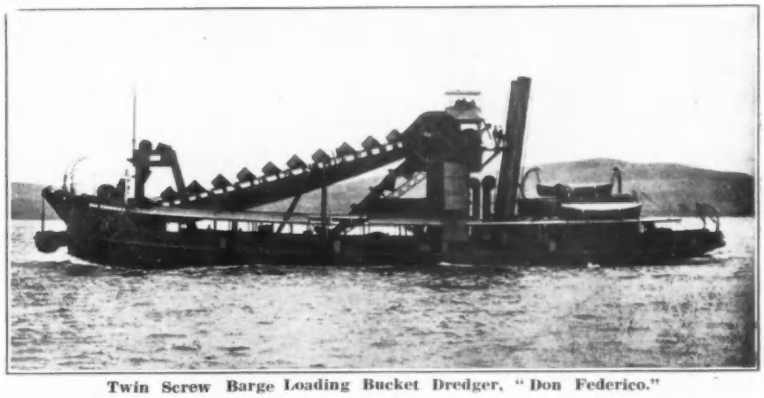
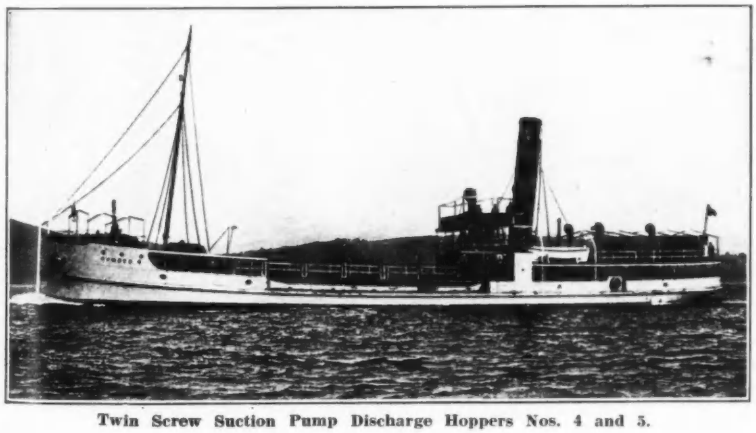


Twin Screw Barge Loading Bucket Dredger, "Don Federico."



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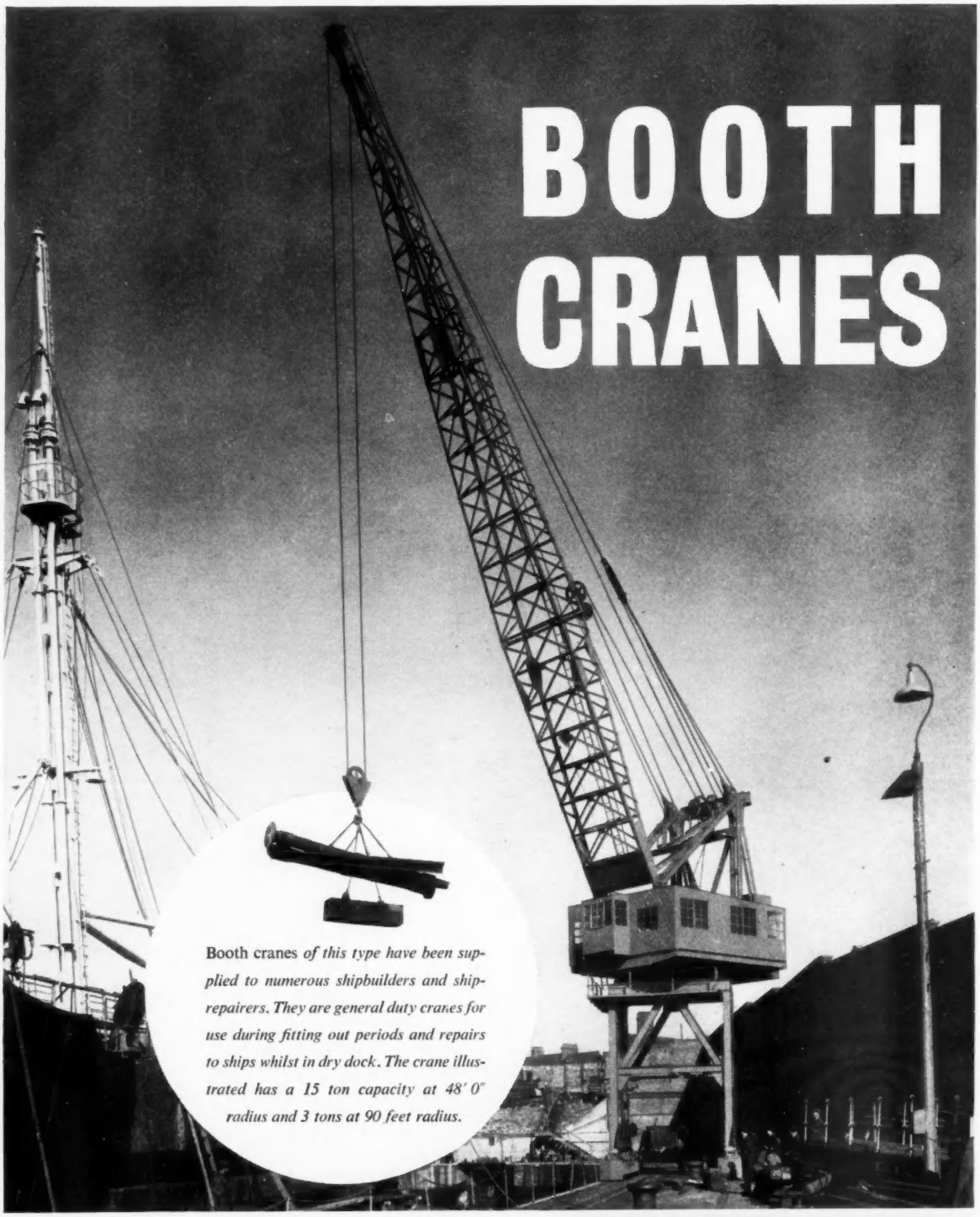

Booth cranes *of this type have been supplied to numerous shipbuilders and ship-repairers. They are general duty cranes for use during fitting out periods and repairs to ships whilst in dry dock. The crane illustrated has a 15 ton capacity at 48′ 0″ radius and 3 tons at 90 feet radius.*

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LEFT TO RIGHT: MISS HONG KONG, MISS HAWAII, MISS UNIVERSE OF 1953 (FINLAND), MISS GERMANY, MISS GREECE

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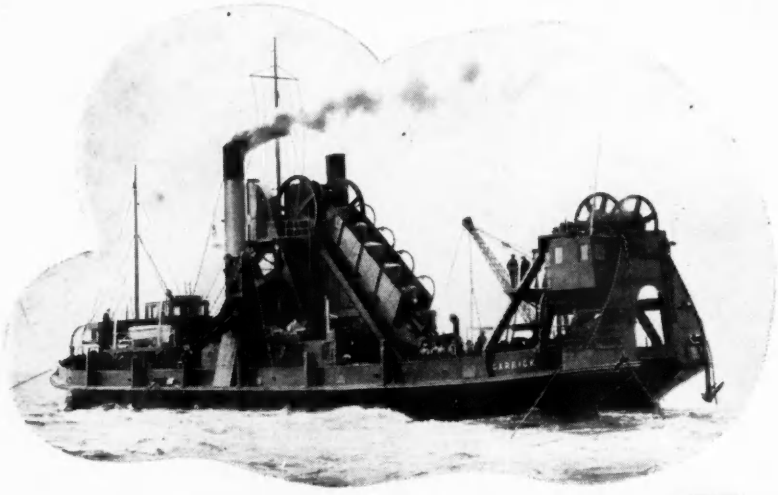

Twin Screw Stern Well Barge loading BUCKET HOPPER DREDGER "CARRICK" constructed for the L. M. & S. Railway Co.

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"*You mean the water actually gets between the paint and the metal?*"

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"*So that's why you sometimes get little lumps of rust under the paint film?*"

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No. 393

Vol. XXXIV.

JULY, 1953

Monthly 2s. 0d.

Editorial Comments

The Port of Freetown, Sierra Leone.

Our leading article this month is devoted to the recent harbour developments that have been carried out at the Port of Freetown, based upon the Briggs Report which, it will be remembered, was the subject of a previous article in an earlier issue of this Journal.

Freetown is one of the principal ports on the west coast of Africa, and is the capital and seaport of Sierra Leone—a Crown Colony of Great Britain. The harbour, which is naturally commodious, is situated in the broad estuary of the Sierra Leone River. It is an important fueling station, bunker coal being supplied by the Sierra Leone Coaling Company and bunker oil by the Shell (West Africa) Company.

Readers will observe that the new developments comprise works of major importance and include, besides the block type quay wall, three transit sheds, the centre one with special facilities for passengers on a second storey, together with two single storey warehouses for the storage of cargo awaiting export and a slipway for the repair of tugs. The use of blocks in the construction of the slipway is worthy of note.

The completion of these works will fulfil a long felt want and will enable cargo and passenger traffic to be handled more speedily. It should prove an invaluable step towards the continued development of the interior of the country which has received an impetus from the additional financial assistance that is now being afforded to the Colonies.

East African Port Facilities.

Readers will remember that the subject of delays experienced by shipping at Southern and East African ports has been mentioned and commented upon in this Journal from time to time. Upon a following page in this issue we are now printing a brief review of certain steps which have been taken to improve existing conditions at the Port of Mombasa and other areas under the management of the East African Railways and Harbours Administration.

With the publication, in a Sessional Paper, of the decisions of the East African High Commission on the recommendations contained in the Report of the Committee of Inquiry into the working of the Port of Mombasa, it is probable that the last word has been said upon what should or should not be done at that port for its improvement.

Naturally, much of the subject matter of the various reports is concerned with purely local problems of a domestic nature. There are, however, several items that are of general interest. The recommendations, comments and decisions, together with our reviewer's remarks upon them, have accordingly been set out in some detail.

It is interesting to note, in connection with the financial aspects of East African port improvement, that it has been announced by the Mutual Security Agency Mission in London that loans amounting to £2,390,000 have been granted by the United States Government, to expand the ports of Mombasa and Tanga. These loans cover half the estimated cost of the works, and the U.K. Government undertakes to expend or cause to expend the other half from funds to be secured by the East Africa High Commission.

As regards the Port of Mombasa, to enable the long-term plans to become effective, it only remains to press on with all speed with the construction of the new deep water berths, transit and storage sheds, the extension of the lighterage wharf and many other works designed to increase the capacity of the port.

Port Plan for Bucharest.

According to a report recently issued by the Roumanian Government, a scheme to connect Bucharest with the sea is to be put in hand this year, and will be begun before the plan to make the River Danube navigable for sea-going vessels has been completed.

In order to convert the River Dambovitsa into a navigable waterway, a canal about 37½ miles long will be cut. A river port will be constructed at the head of this canal, at Popesti-Leordeni on the outskirts of Bucharest, and it will be equipped with quays, a railway station to accommodate passenger and goods traffic, and storerooms and warehouses.

The authors of the project plan to use the valleys of the small and at present, unnavigable rivers, Dambovitsa and Arges, to link Bucharest with the Danube at Oltenitsam. This will involve the removal of 30 million tons of earth and the conversion of the small stream which is only a few yards wide, and two or three yards deep at its flood, into a canal between 50 and 60 yards wide and deep enough to take the large river ships which will be using the Danube in the near future. The main obstacle to the scheme is lack of a good water supply, and to overcome this, the clearing and linking of the lakes of the Colentina River with the Jalomitsa would considerably enlarge the flow of the Dambovitsa River.

A further advantage which the Roumanian Government hope to gain from these plans, is the irrigation of a large area of alluvial plain near the city.

The Problem of Fire Prevention.

The incidence of fires continues to be a problem of pressing importance both in domestic and industrial premises. Consideration of the cost of damage caused in recent years shows the extreme importance of taking every possible precaution to prevent fires occurring, and if they should break out, the necessity of extinguishing them as soon as possible.

As we have repeatedly emphasised in these columns, docks and harbours constitute a concentration of fire risks of proportions not met with in industrial areas, and therefore fire prevention in dock premises and ships is of the greatest importance.

"Fire Research, 1952," was published early this month by Her Majesty's Stationery Office for the Department of Scientific and Industrial Research and the Fire Office Committee. It includes the Report of the Fire Research Board, and also of the Director of Fire Research for the year, and contains data and information which should be widely disseminated. For example, the Report states that at least two out of three fires which break out in buildings are due to carelessness and could be avoided. One fire in six during a five-year period up to 1951, was associated with electricity and the report points out that the majority of fires caused by electrical equipment were also caused by carelessness or incompetent handling of the apparatus.

The behaviour of pre-stressed concrete beams subject to high temperatures, is of particular interest to those concerned with modern buildings in which these members are being increasingly used. A systematic study of the problem is being made at the Fire Research Station and some useful data is included in the Report.

Editorial Comments—continued

Investigations of the smouldering of various types of materials, as a prolific cause of delayed outbreaks of fire, have been carried out during the year, and the results achieved are particularly valuable.

A further important series of experiments dealt with fire extinction, in particular by water sprays and various types of foams from protein and other components. An interesting method of fighting fires in large oil storage tanks is also being investigated, and seems to offer some important possibilities.

The Development of Mexican Pacific Ports.

Following the visit of a Canadian Trade Mission to Central and South American countries, it has been suggested that the development of the four principal Mexican ports situated on the Pacific coast—Mazatlan, Manzanillo, Acapulco and Salina Cruz—should be financed by Canadian capital.

An arrangement of this nature would be of primary importance to Mexico's economy, as it would immediately open new markets in Canada for Mexican-produced goods and lead to a considerable increase in trade between the two countries. The facilities at present available at ports on Mexico's Pacific Coast do not permit the entry of ships of deep draught. At the same time, Canada cannot compete with the lower United States prices since transport across the U.S.A. borders would be a costly affair and economically impossible. This factor appears to have been the chief stumbling block to greater trade in the past.

The Canadian Mission is said to have offered the capital necessary to dredge and rehabilitate the port facilities of the four ports mentioned, and in addition would construct silos, transit sheds and warehouses. Mexico would then be in a position to exchange manganese ore, which is found in abundance in the State of Jalisco for Canadian wheat.

The full-scale development of Acapulco is suggested as an initial step. Canadian observers feel that this seaside resort which is situated close to the huge iron deposits in Michoacan, and to deposits of coal in Oaxaca and Guerrero, and also has certain port installations already in existence, could rapidly be converted into an important maritime centre. After Acapulco, the facilities at Salina Cruz would be developed.

It is reported that the new regime of President Adolfo Ruiz Cortines is interested in building up port facilities, but is hampered by lack of capital, so, no doubt, that is why the Canadian proposal has been welcomed. Should the scheme materialise the venture should prove very profitable for both countries

Port Trust for Mangalore.

A Bill to constitute a Port Trust for the Port of Mangalore was recently published by the Madras Government. The statement of objects and reasons says that among the minor ports which are under the control of the Government of Madras, the Port of Mangalore is second only to Tuticorin which is administered by a Port Trust, a statutory body constituted under the Tuticorin Port Trust Act, 1924. Mangalore, however, is administered by the Mangalore Port Conservancy Board, which is administratively subordinate to the State Port Officer.

The conditions which obtained at Tuticorin when the Port Trust was formed, exist now at Mangalore, and representations have been received from the Kanara Chamber of Commerce and other local interests urging the constitution of a Port Trust so as to increase local autonomy in the matter of administration. It is considered necessary, therefore, to constitute a Trust Board and to apply the Tuticorin Port Trust Act to Mangalore.

It is also reported that Mangalore is to be developed as an all-weather port. At present it consists of an open roadstead and an inner harbour. There is a bar at the entrance, so that ships have to lie at anchor outside, and passengers and cargo have to be conveyed by lighters or small boats to the inner harbour, where a depth of 10-ft. is maintained.

The Central Water and Power Research Station, Poona, has constructed a model of the Mangalore Port and investigations have been carried out to enable problems concerning the planning of the new port to be resolved.

These developments, without doubt, should prove of immense value to the West Coast of India, as at present there is no good harbour between Bombay and Cochin. The new port will also serve the hinterland of Karnatak, Mysore and other surrounding areas, where cashew nuts, cardamum and other materials are exported on a large scale.

Topical Notes

Hartlepool Dock Improvements.

The Docks and Inland Waterways Executive has recently placed a contract, valued at approximately £300,000, for the construction of a new lightening berth for vessels entering Hartlepool Docks.

The civil engineering work involves dismantling the existing timber lightening berth, built in 1913, and providing additional sidings and rail access. The new quay proper is some 650-ft. long by 80-ft. wide, and is divided into two main types of construction. At both the eastern and western ends there is a section comprised of reinforced concrete piles with heavy deck-slab. The central section of the berth, which is 480-ft. long is split into two sections. The outer section involves the construction of 6-ft. diameter reinforced concrete columns founded on piles driven into the harbour bed. These are joined across the top by deep portal beams which carry the main decking and crane rail beams. This type of construction will involve sinking 9-ft. diameter cylinders into the harbour bed and subsequently driving piles and constructing the main columns within the protection of these cylinders.

The rear portion of the main quay consists of a normal piled reinforced concrete relieving platform which will carry the rail tracks serving the berth. This work will involve piling in some places through an old sluice-way which has been in operation for over one hundred years.

The fendering is provided by steel box piles linked together and carrying fenders and rubbing timbers, the whole acting against compressed rubber buffers which in turn transmit the berthing impact to the main quay.

The work is due to start immediately and will be carried out under the direction of W. McKenzie, M.I.C.E., Chief Docks Engineer, Docks Office, Victoria Square, Hull. The contractors are John Howard and Co. Ltd., 13, Buckingham Gate, London.

Proposed New Port for French Togoland.

A new port which it is hoped will bring increased prosperity to the country is under consideration by the Assembly of French Togoland. Recent discoveries of large quantities of phosphate at Anécho would provide an export amounting, it is estimated, to some 250,000 tons per year, and to attain this total, a new port is considered essential.

The deposits of phosphate are near the coast, and the new port would be situated between Agoué and Grand-Popo. In this position it could from the outset rely on an additional tonnage of goods coming from or going to Dahomey, as Cotonou now has a transit traffic of some 180,000 tons per annum. A railway along the coast from Lomé to Cotonou would join the new port with the Togo and Dahomey railways. The only port at present available is Lomé, but this is subject to expensive delays.

Nigerian Creek Ports.

In order to reduce the cost of cacao movements, the capacity of the creek port of Agbabu, in Ondo Province, Nigeria, is to be improved. This Province produces some 14,000 long tons of cacao each season, and, up to the present time, this has been transported by road to Lagos at considerable expense.

Plans are now being made to improve river facilities to enable lighters to be loaded at Agbabu and towed to Lagos for transhipment of cargo. These new facilities, which are anticipated to produce substantial savings in transport costs, are expected to be completed in readiness for the 1953-54 cacao-buying season. The undertaking is sponsored by the Nigeria Cocoa Marketing Board, the Nigeria Marine Department, and the Ondo Native Authority and it is hoped that similar projects will be carried out later at other creek ports in the western region.

The Port of Freetown, Sierra Leone

Description of Recent Harbour Developments

IN the December, 1947, issue of the "Dock and Harbour Authority," an article was published on the report of the Briggs Committee regarding the proposal to construct a deep water quay at Freetown. The Consulting Enginers were instructed to prepare the necessary designs and documents in August, 1945, and in July, 1947, tenders were invited from six firms of civil engineering contractors.

The contract was awarded in March, 1948, and work commenced at the site in May, 1948. This article describes the works that have been carried out since that date.

The main recommendation of the Briggs Committee was for a quay wall, 1,200-ft. in length, providing two berths, each of 500-ft. in length, for cargo vessels and one berth of 200-ft. for colliers or coastal steamers, with 32-ft. of water alongside the quay at low water ordinary spring tides.

The plan on page 69 shows the layout of the works as finally constructed. The first 110-ft. of the quay wall at the east end was constructed of mass concrete inside a steel sheet piled cofferdam. This type of construction was adopted due to the fact that the foundation was not so firm as over the rest of the length of the quay. Due to the presence of silt the contractors were unable to dewater the cofferdam and the excavation for and the concreting of the wall was carried out by divers inside the steel piling.

The remainder of the wall was constructed of precast concrete blocks laid in horizontal bond on a bed of concrete of an average thickness of 1-ft. A typical cross-section of the wall was shown in the December, 1947, issue of this publication. Some 5,800 blocks were made and set in the wall, the seaward blocks, in each course being tied together by means of concrete in bags placed by divers in the joggles formed in the sides of the blocks. The blockwork was carried up to 4-ft. above L.W.O.S.T. and the remaining 12-ft. of the wall, that is up to 16-ft. above L.W.O.S.T. was constructed of mass concrete deposited behind a facing of moulded concrete blocks, these latter blocks being set and pointed to line and level by local masons.

Immediately behind the wall rubble backing, of local syenite, was deposited to relieve the pressure of the filling on the wall. The filling behind the wall was mainly obtained from the cliff in the rear of the area which had to be cut back to provide the necessary level area for the construction of the transit sheds, roads and rail tracks.

The wall is provided with hook-type cope bollards at 60-ft. centres and ladders, fixed in grooves, at 180-ft. centres. Due to the effect of the water in the harbour on timber no fixed fendering has been provided, but the Harbour Authorities propose to provide circular hanging fenders, and for this purpose eye-bolts have been cast in the coping stones at 12-ft. centres.

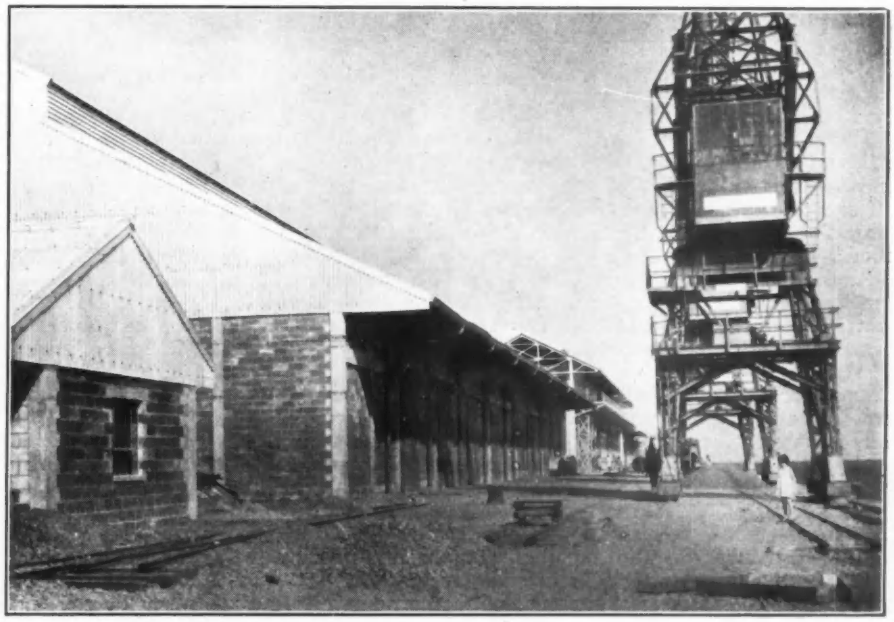
The width of the quay from cope line to the face of the sheds is 60-ft., and in this area three rail tracks to the local 2-ft. 6-in. gauge have been laid flush with the macadam surfacing. In addition crane rails at 15-ft. centres have been laid for the full length of the quay.

Below the quay surfacing and between the second and third rail tracks, a pipe and cable subway, 4-ft. wide by 4-ft. 6-in. high, inside measurements, has been provided with access manholes and removable cover slabs. This subway carries the electric power cables for the wharfside cranes, and also a 6-in. diameter water main, branches being taken off the latter at 180-ft. intervals to twin hydrants housed in chambers adjacent to the cope. These hydrants can be used both for the watering of ships and as fire hydrants. Provision has been made in the subway for the fixing, at a later date if required, of oil pipes either for bunkering ships or for the export of palm oil in bulk. To save cutting through the concrete superstructure at a later date, 4-in. diameter oil pipe branches have been built in from the subway to oil chambers along the cope at 120-ft. centres. A subway also runs from the foot of the cliff, between sheds Nos. 1 and 2, and connects into the main subway along the quay.

In addition to these facilities four one-ton electric capstans and two fairleads have been built in on the line of the subway to facilitate the movement of railway wagons being loaded or unloaded on the quay. A further amenity is the provision in the length of the quay of four telephone plug boxes providing ship to shore telephone communication.

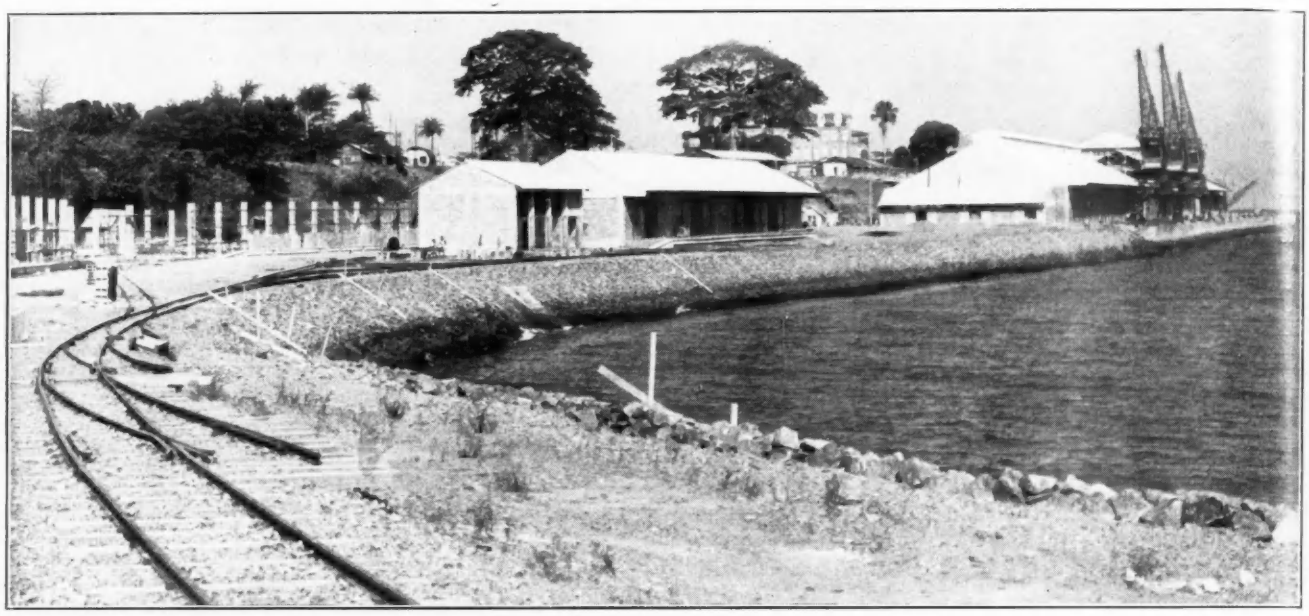
Three transit sheds have been constructed along the quay all 75-ft. wide. The two outer sheds are single-storey, 300-ft. long, and are constructed of mild steel columns, with concrete surround, and mild steel roof trusses, the roofs being covered with corrugated asbestos sheets. A cross-section of these sheds is shown in the plan on page 69 and the photograph on page 67 shows the front of the eastern shed. The walls and gable ends of the sheds are constructed of concrete hollow blocks, 9-in. wide, and eight double sliding doors are provided on the landward and seaward sides, the door openings being 14-ft. wide by 12-ft. high. A rail platform is provided along the rear of the sheds and the floors of the sheds slope up from the front to the back at a slope of 1 in 60. Each shed is provided with two weighing machines and expanded metal cages will be constructed at a later date for the storage of broken cases and for customs examination.

The centre or No. 2 shed is double-storey and is 340-ft. long, but only the ground floor is for cargo. This shed is of similar construction to the single-storey sheds, the upper floor being of reinforced concrete. Two cross-sections of this shed are shown in the plan on page 69, one being a cross-section through the centre of the shed. The two photographs on pages 70 and 71 show



View of Deep Water Quay looking west from Store Shed.

Port of Freetown, Sierra Leone—continued



View of New Deep Water Quay from rubble bank, looking west.

the front and rear elevation of the shed shortly before completion.

The ground floor of the shed is split into two halves by the provision of a Queen's Warehouse 70-ft. long by 48-ft. wide, and an entrance hall with a flight of steps to the upper floor. An electric lift of 6,000 lb. capacity is also provided for the transport of passengers' baggage to the Customs Examination Hall on the upper floor.

At the top of the staircase is a waiting hall where passengers can stay before proceeding through the Customs, and where passport, postal and tourist information facilities are provided. Having passed through the Customs examination hall passengers proceed across the footbridge shown in the photograph on page 71, to the car park area indicated on the plan. Here a passenger shelter is provided and a one-way road around the car park facilitates the easy movement of cars and taxis calling for or dropping passengers.

On each side of the Customs hall are suites of offices with a corridor down the centre of the building. Half of these offices are for the Port Authorities, such as harbour master, pilots, customs, railway and police officials. The other half will be rented to various shipping firms and importers. In the rear of this shed, on the upper floor, two blocks of staff lavatories are provided, and mild steel staircases at the ends of the corridors give quick access to and from the quay. At quay level at each end of the shed lavatories are provided for the labour working on the quay.

Behind the transit sheds is a roadway some 75-ft. wide, with three further rail tracks, one being immediately alongside the platforms in the rear of the sheds. All rail tracks are laid flush with the surface to enable road traffic to approach the sheds.

The photograph on page 68, shows a view of the whole quay looking from the east end of the reclaimed area. A rubble bank, 10-ft. wide at the top, with side slopes of $1\frac{1}{2}$ to 1 was constructed on the outer face of the reclamation area and filling obtained from the excavation of the cliff, the access road and the foundations for the quay wall was deposited behind the bank. A total of 220,000 cubic yards of material was deposited behind the wall and in the reclamation area.

Open drains have been provided along the foot of the cliff, at the sides of the access road and adjacent to the shed platforms and these, together with other drainage, are led to the main outfall drains which run between the sheds and discharge through the quay wall, or, in the case of the reclamation area, through the rubble bank.

Various other buildings and facilities have also been provided and these may be seen on the plan on page 69. A shed, 200-ft. long by 30-ft. wide, has been constructed at the east end for the storage of cement and bulk salt, a partition wall being provided to separate the two commodities. Just east of this shed and also at the west end of the quay two garages for mobile cranes have been constructed, each with a small workshop attached. East of No. 1 shed a small store has been built for use by the Harbour Master and Railway Authorities for the storage of ropes and similar tackle.

In the rear of shed No. 1, a 30 tons road and rail weighbridge has been provided, together with a small fire pump house, where will be garaged a fire engine and two trailer pumps. At the west end of the site a washhouse and two mess sheds have been constructed and a store for the shipping companies' gear, such as scale-boards and nets.

Farren Jetty, at the extreme west end, has been used by the contractors for unloading much of their plant and equipment from lighters. This jetty was in existence at the commencement of the works and it is being retained and brought within the Customs area. Rail connection from this jetty to the front of the quay and the back of the sheds has been provided and the road in the rear provides additional access to and egress from the quay. A small petrol tank and pump has been provided in this area.

Instead of the usual septic tanks to be found on the West Coast of Africa, the whole of the sewage from the various lavatories will be dealt with by two 8-in. horizontal Gargantua disintegrators, electrically controlled and discharging into the harbour through a pipe running from the disintegrator pit to the mooring dolphin.

The whole area is surrounded by a chain link fence 7-ft. high, with an extension arm carrying three strands of barbed wire. Gates are provided at the access roads and for rail tracks, and police boxes have been provided where necessary. The front of the quay, the sheds and access roads are all provided with adequate electric lighting, and fluorescent lighting and fans have been provided in the upper floor of shed No. 2.

Three wharfside electric level-luffing travelling portal cranes have been installed on the quay, two of the cranes being of 3 tons capacity and one of 5 tons. These cranes have a maximum radius of 60-ft. giving an outreach from the face of the quay of 47-ft. 6-in. One of the 3-ton cranes and the 5-ton crane are provided with grabs for unloading colliers.

For the berthing and unberthing of vessels two twin-screw diesel-driven tugs have been built. These tugs have been constructed primarily for dealing with shipping up to 12,000 tons gross, but the design is such that they will be able to proceed to sea for

SIERRA LEONE – FREETOWN
DEEP WATER QUAY ETC.
KEY PLAN
SITE OF DEEP WATER QUAY
Cline Point
CHROME ORE JETTY
SLIPWAY
CLINE STREET
WHARF ROAD
CLINE BAY
CLINE TOWN
Railway Sta. & Workshops
Hospital
COLLEGE ROAD
FOURAH BAY COLLEGE
Fourah Pt.
Scale of Feet
CROSS SECTION – SHEDS 1 & 3
Inclination 1 in 60
75'. 0"
Scale for Sheds 1 & 3
FARREN JETTY
Mooring Dolphin
EXISTING ROAD
RAILWAY DEPT. OFFICES
CAR PARK
Passenger Shed
PASSENGER FOOTBRIDGE
SHED No 3
SHED No 2
SHED No 1
DEEP WATER QUAY
WAREHOUSE No 1
CEMENT SHED
STORES
Weighbridge
Mobile Crane Garage
WAREHOUSE No 2
CLINE STREET
SHED No 2
CROSS SECTION THROUGH CENTRAL TOWER
WAITING HALL
ENTRANCE HALL
LIFT SHAFT
MOTOR ROOM
EXAMINATION HALL
QUEEN'S WAREHOUSE
PASSENGER FOOTBRIDGE
Sliding Door
Swing Door
Window
Ventilator
CROSS SECTION THROUGH OFFICES
OFFICE
CORRIDOR
WAREHOUSE
Scale for Plan
Scale for Shed No 2

Port of Freetown, Sierra Leone—continued

rescue services or salvage operations. One tug has been provided with a 10-ton derrick for handling buoys and moorings. The principal dimensions and leading particulars of these tugs are as follows:

Length	110-ft.	Draught-forward	9-ft. 6-in.
Breadth moulded	30-ft.	aft	12-ft.
Depth moulded	14-ft. 6-in.	B.H.P.	1,000
Gross tonnage	306	Speed on trial	11.5 knots
Static pull, ahead	14.0 tons	Propeller diameter	7-ft. 2-in.

In order that these tugs may be adequately maintained a slipway has been constructed and the siting of this in relation to the deep water quay is shown in the quay plan on page 69.

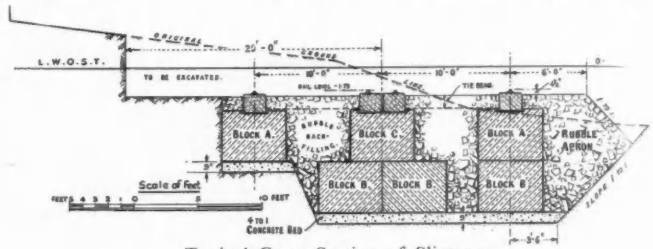
A typical cross-section of the slipway is shown on page 70. A concrete bed, 9-in. thick, was laid on the prepared foundation, and precast concrete blocks, 8-ft. long by 5-ft. wide by 4-ft. high, were laid by divers. The ends of the blocks are made with tongues and grooves and the upper faces of the top courses are recessed to take the precast reinforced concrete beams, which carry the rails and pawl rack for the slipway cradle. The beams are 1-ft. 9-in. wide by 1-ft. 6-in. high, and are made in lengths of 24-ft. Two beams, one for the outer rail and one for the centre rail, are cast as one unit with three 6-in. by 12-in. reinforced tie-beams. The recess in the upper face of the blocks allows room for packing and wedging the reinforced concrete beams to line and level, the beams being finally grouted in position. The rails for the cradle are 70 lb. per yard bridge rails fixed by means of rail clips bolted to the beams. The tie-beams are covered on the upper face with steel rubbing strips to prevent wear both to the beams and to the haulage rope.

The slope of the slipway is 1 in 16, the level of the rails at the lower end being 15.20-ft. below L.W.O.S.T. and the total length is 512-ft.

In addition to the main tug slipway a small launch slipway has been provided for dealing with the various harbour launches. This slipway is at a slope of 1 in 11 and has an overall length of 180-ft., the level of the rails at the lower end being at L.W.O.S.T. The rails are 24 lb. per yard bridge rails fixed by rail clips to concrete beams cast in-situ, 30 lb. per yard second-hand rails being used as ties between the beams. The upper 75-ft. of this slipway is covered by a mild steel framed building 20-ft. wide, with asbestos cement roof sheeting and sides, and a 2-ton overhead hand-operated travelling crane is provided for removing the engines from launches.

A rubble bank, similar to that for the deep water quay, has been constructed to enable an area approximately 230-ft. by 1[illegible]-ft. to be reclaimed. In this area a machine shop, carpenters' shop, blacksmiths' shop, office and garage for mobile cranes are to be constructed in addition to the winch house for the haulage machinery.

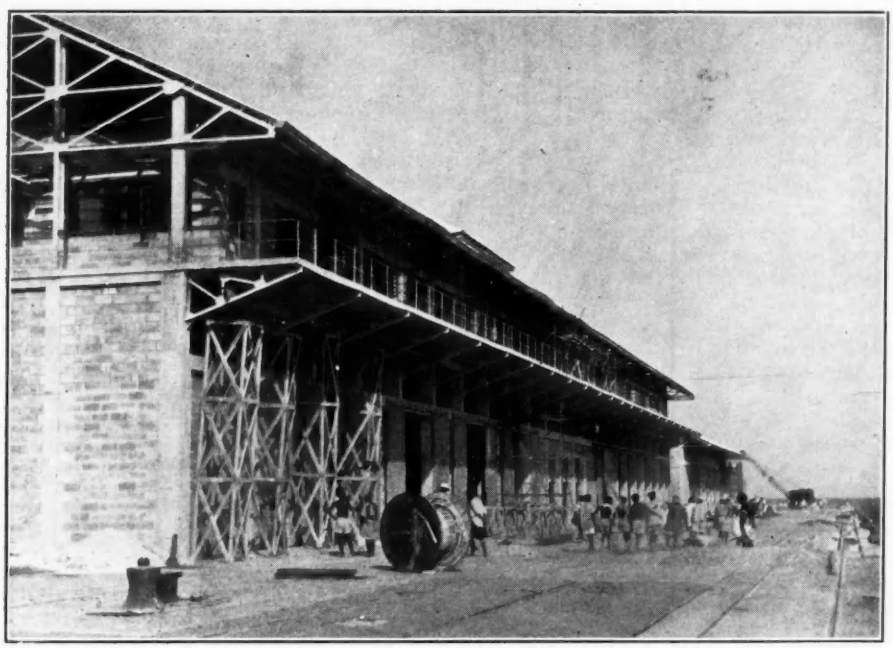
The haulage equipment which is electrically-operated will provide for an estimated pull of 57 tons at the main drum, the speed of haulage at full load being 10-ft. per minute. The diameter of the drum at the base of the grooves will be 4-ft. 10 13/16-in., and



Typical Cross Section of Slipway.

the main wire rope will have a circumference of 6¾-in. An additional drum for the launch slipway cradle is to be provided for hauling a load of 50 tons at a speed of 15-ft. per minute ; this drum being independently geared, with the haulage wire passing through fairleads to the top of the launch slipway.

At the east end of the deep water quay in the rear of the reclaimed area, two warehouses are being constructed for the Sierra Leone Produce Marketing Board for the storage of palm kernels and the like awaiting export. One shed is 520-ft. long and the other 236-ft., both being 60-ft. wide with a height to eaves level of 33-ft. The sheds have reinforced concrete columns at 15-ft. 9-in. centres carried on reinforced concrete foundations. The roofs are of mild steel trusses covered with corrugated asbestos sheeting and the walls are of 9-in. thick concrete hollow blocks. Sliding doors are provided on both sides of each shed in alternate bays, the door openings being 14-ft. 6-in. wide by 14-ft. high. Each shed has a rail platform 9-ft. wide on each side, the platforms being protected by the continuation of the roof sheeting as a canopy. The longer of the two sheds is split into three separate compartments and the shorter into two by means of concrete block fire party walls. A mess shed and lavatory accommodation are provided in separate buildings, and a 50-ft. wide road runs along the north side of the sheds. The whole area is surrounded by a chain link fabric fence 7-ft. high similar to the Customs fence around the deep water quay area, to which it is connected at the east and west ends. A separate access road with entrance gates and watchman's hut is provided at the extreme east end.



View looking west from east end of Shed No. 2.

The three civil engineering contracts, namely the deep water quay, the slipway and the warehouses have been carried out by Messrs. Pauling and Co. Ltd. The deep water quay was substantially completed on 31st May, 1953, and on 3rd June, His Excellency the Governor of Sierra Leone re-named the quay the "Queen Elizabeth II Quay." The contract for the slipway, which was awarded to the contractors on 3rd July, 1951, is due to be completed by 31st October, 1953, although the haulage machinery may not be installed until the end of the year. The contract for the warehouses was awarded to the contractors on 3rd April, 1952, and is due to be completed by 31st October, 1953.

The three wharfside cranes, which did not form part of Messrs. Pauling and Co's. contract, were manufactured and erected by Messrs. Cowan Sheldon and Co. Ltd. and they completed the erection by January, 1953.

Port of Freetown, Sierra Leone—continued

The two diesel-driven tugs, which have been named ***Fourah*** and ***Farren*** were built by Messrs. Henry Robb, Ltd. of Leith and, although these tugs have been completed, they will not be sent out to Freetown until about September, 1953, that is shortly before the slipway is due to be completed.

The three civil engineering contracts, the contract for the cranes and that for the tugs were carried out for the Government of Sierra Leone through the Crown Agents for the Colonies. The consulting engineers were Messrs. Coode and Partners of Victoria Street, London, and this firm also drew up the specification for the cranes and acted as consulting naval architects for the construction and testing of the tugs.

It is anticipated that the necessary port organisation will have been formed by October, 1953, when these new facilities will be put into operation thereby providing Freetown with its first deep water berths. The works have necessitated the employment of an average of 700 to 800 Africans and 30 to 40 Europeans since 1948. The divers employed on the setting of the underwater work were Europeans but Africans have been employed on various cranes and machines and have undertaken all the various trades such as masons, carpenters, plumbers, fitters, etc.

View of Deep Water Quay looking west, landward of sheds.

It may be of interest to list some of Messrs. Pauling and Co's. principal contractors:

Steelwork for Sheds Nos. 1 and 2 and ancillary buildings	Burton Constructional Engineering Co.
Steelwork for Shed No. 2	P. and W. MacClellan Ltd.
Weighbridge	E. and A. Ashworth Ltd.
Lift	J. and E. Hall and Co. Ltd.
Sewage Disintegrator	Hathorn Davey and Co. Ltd.
Capstans and Fairleads	Stothert and Pitt, Ltd.
Haulage machinery and cradle for slipway	Head Wrightson and Co. Ltd.
Steelwork for Warehouses	E. C. and J. Keay Ltd.
Asbestos Roof Sheeting	Turners Asbestos Cement Co.
Cement	Cement Marketing Co.
Rails and Switches, etc.	Robert Hudson Ltd.
Crane Rails and Fittings	Anderston Foundry Ltd.
Fencing	Darlington Fencing Co.
Electrical Equipment	General Electric Co.

Quayside Equipment of Ports

Differing Conceptions in Europe and America*

By J. VASSEUR, Port Engineer, Port of Havre.

In his opening remarks, the author draws attention to the sharp contrast which is frequently noted between European and American ideas on port equipment, and points out that from the American viewpoint, the investment on quayside cranes in the European manner, costing about £1,000 per yard of frontage, is not justified. Reference is made to previously published work in " The Dock and Harbour Authority," " Hansa " and in particular an article by M. Baudelaire, Engineer in Chief, in " Navires, Ports et Chantiers " Nos. 19 and 20. After stating that the interdependence of lifting gear, road and rail facilities and warehouse arrangements make it impossible to consider the problem solely in terms of lifting gear, the author proceeds to a comparative study of the various solutions adopted in Europe and America to the problem of handling mixed cargoes.

France: Following the extensive destruction of port equipment in 1944 opportunity has been taken to put some new ideas in practice during reconstruction. The berths are on long quays, of concrete or, more rarely, rust-resisting steel. The railways are always double track, with tracks at the rear of the sheds. The floor space of quay and shed combined is never less than 43,000 sq. ft., and is on occasion 78,000 sq. ft. and more. The shed may extend back as much as 330 feet, and advantage is taken to make the greatest possible use of mechanical handling gear. Sheds of more than one storey have been abandoned, on account of prime cost and cost of vertical handling.

All quays have cranes except where lack of finance has so far prevented this. The cranes are rated at 3 to 6 tons at 6-ft./sec. on light load. They are arranged to bestride the railway tracks. The outstanding example of French post-war practice may be seen at the Quai Hermann du Pasquier, at Havre.

Germany: Reference is made to the German practice of avoiding the use of ships' gear, and the profusion of cranes which is to be found, up to five cranes per berth. The cranes are arranged to reach the front of the sheds, thus avoiding the need for metalled railway lines or space for road traffic. A high platform alongside the shed is provided for reception of pallets. The advantage here is that goods can be disposed of simultaneously, into the shed or outwards into the railway trucks with equal ease. The Germans reckon, and with some justice, that the money lost by such concentration is more than recovered by the economies which result from better utilisation of shed space, and from the ease with which anti-pilfering measures can be enforced.

America: The construction and layout of American piers, with their lack of cranes, light construction and arrangements for " burtoning " are described, on lines which will be familiar to readers, from recent articles in " The Dock and Harbour Authority."

M. Vasseur goes on to discuss the advanages of cranes, as seen by European operators, with particular reference to European tidal ranges, and the needs of direct transhipment. (This section is in essence similar to what appears in Neumann's articles in " The Dock and Harbour Authority," June and July 1952.) The writer then goes on to assess the profitability of a quayside crane, and gives detailed figures for French operation. (Since the wage scales and social charges are peculiar to France the detailed figures are not given here.) M. Vasseur concludes that the lowest pro-

*Condensed from the author's article " Diverses Conceptions sur L'Aménagement des Quais des Ports Maritimes," in " Navires Ports et Chantiers " Paris, June 1952.

Quayside Equipment of Ports—(continued)

duction which makes the installation of a crane worth while is 17.7 tons per hour, in doing which the crane secures an overall increase in output, of 18 per cent.. This figure is contingent on a low utilisation figure of 1,000 hours per annum. If however the crane is used for 2,000 hours, the overall costs of the crane could be met by an increased output of 8 per cent.; on a utilisation of 1,500 hours per annum the required increase will be 12.5 per cent. So much for the crane in simple ship to shore handling.

If however a substantial proportion of the trade is intended for direct transhipment, the advantages of a crane are more marked. The substitution of direct transhipment, via crane, for double handling would result (on a basis of 1,500 hours use, and assuming one third of the cargo to be for transhipment), in savings which would reduce the hourly cost of the crane to a figure below that of the minimum cost of operating ships' tackle.

While admitting that there are many other factors which tend to make such calculations academic, M. Vasseur concludes this section by stating that in general it will pay to instal a crane in situations where the output is thereby increased by five to ten per cent., and where direct transhipments can be brought up to 20 per cent.; a minimum use of 1,000 hours per annum is required.

M. Vasseur next discusses the cost of the " infrastructure," a term which is taken to include all heavy constructional work involved in creating a quay, including necessary dredging and widening operations. On the thesis that cranes enable a better exploitation of the quay, and thus lowers the cost of the structure, the installation of cranes is taken to be justified. Reference is made to an article in " Hansa " (April 28, 1951) where German engineers report the conclusion that, after taking all unavoidable losses into account, the presence of cranes enable the length of wharves to be reduced by 20 per cent. Hence, taking crane equipment at £1,000 per metre, and infrastructure cost at £4,000 per metre (European ports), 125 metres of wharf without cranes can be replaced without extra cost by 100 metres with cranes.

The author would however prefer to take such a conclusion with a pinch of salt, since he suspects that output figures from Bremen and Hamburg may be the result of exceptional quality of labour and stevedoring organisation in those ports, and that it would be dangerous to apply the German calculations to ports in countries where the organisation and employment of labour is, as yet, backward. Further, the argument takes no account of the advantages which accrue from increasing the length of quays, to allow for simultaneous reception of more ships, which he regards as a precious facility in a trade where irregularity of arrival and departure is a characteristic feature. Finally the author feels that while, with the above reservations, the German argument might hold in countries where the cost of the infrastructure is high, namely in Europe, the argument would not hold water in America where the cost of cranes would be disportionate to the other works, which are relatively light and cheap.

Hence, as a general conclusion, M. Vasseur would prefer to fall back on the simpler argument enunciated earlier in his article, namely that a crane can earn its keep only when it is used a minimum of 1,000-1,500 hours, and in situations where there is a substantial body of direct transhipment.

There follows a discussion of the ability of a private or public owner of cranes to recover the cost of their installation, in which the author refers to the difficulty in which a shipowner, who is also a crane operator, is placed by being unable to secure a good load factor, at times when his own ships are not alongside. There is also instanced the predicament of a crane owner, whose object is to make a profit. M. Vasseur concludes that the installation of cranes is best carried out by the port authority. In this way the cranes form a part of the total amenities, and their operating costs, including amortisation, can be met by indirect charges in the way of port dues. In such cases there is no need for the cranes to show an actual profit. Such conditions are now to be found in some European ports, but they rarely occur in America where the methods of port administration bear the stamp of a different conception of economic freedom and administrative duty.

Returning to the question of crane use in hours per annum, M. Vasseur states that 1,500 hours a year corresponds to a 50 per cent. occupation of the quay. This figure is for cranes working in pairs; if they worked singly, the occupation would be 100 per cent., which is both inconceivable, and would lead to hopeless congestion. Hence, he argues, the best solution is to be found in the use of long quays, at which the number of cranes is carefully matched to the estimated or actual work, so as to achieve a happy mean between the cranes' load factor, convenience to shipping, and the disposal of goods from the sheds. Such conditions can, of course, never be secured on American piers where there is room for only one ship on each side.

Finally, M. Vasseur concludes that in Europe, in general, cranes have been installed by rule of thumb or to comply with local tradition, and without a due regard for the economics of the problem. In particular the German example of lavish quayside equipment should be imitated with caution; in French ports on the other hand there is cause for congratulation, in that the arrangement of quays, sheds and cranes is the most rational, economic and flexible, and is, in conjunction with ships' gear, most able to cater for the varying needs of the moment.

Correspondence

To the Editor of *The Dock and Harbour Authority*.

Sir,

Prefabricated Piers

I have read Mr. Buck's interesting letter which appeared in your April issue. He appropriately suggests that the advantages of the DeLong Dock, similar to the advantages of any other particular type of construction, are usually affected by many conditions including conditions at the site of construction, labour and materials market, prices in different locations, etc. He goes on to state that an examination of costs for a similar form of construction in England indicates that the advantages of shop construction of large pieces combined with simple methods of site erection, resulting in reduced overall costs may be absorbed in the high cost of transporting the units. As Mr. Buck can well appreciate, it is difficult and unwise to attempt to make cost comparisons unless the several installations and all conditions attached thereto are so similar as to be able to make true comparisons and not just theoretical comparisons.

The towing costs are not prohibitive and while they, of course, add to the cost of the work, depending on the length of the tow, such costs are not a substantial percentage of the cost of the dock even though, for example, in the case of the Greenland project the tow was approximately 5,000 miles and the Orinco River tow was about 3,000 miles.

The maintenance of the exposed steel surfaces in relation to those of concrete is possibly in favour of the concrete work, but we have found that proper maintenance of such steel surfaces results in an indefinite life at not great cost whereas concrete work, especially in tropical waters is also subject to damage and therefore also requires certain maintenance work, sometimes of considerable magnitude.

Yours very truly,
H. P. MAXTON
Vice-President.

The DeLong Engineering and Construction Co.,
29, Broadway, New York, 6, U.S.A.

18th June, 1953.

New Turning Basin for Houston, U.S.A.

The construction of a new turning basin in the Houston ship channel, to provide for the anticipated growth of the port, has recently been considered by the Harris County Navigation District. Three sites as a possible location, all considerably further downstream than the present turning basin, are under review. Two of the sites have been given approval by the United States Corps of Engineers, while the third site has been recommended by several members of the commission. No estimate has been made as to the possible cost of the development of any of the three sites, but the cost of dredging would be borne by the Federal Government. It is estimated that two or three wharves could be constructed on the banks of the new turning basins at a cost of between four and six million dollars.

Photographs by courtesy of Tate and Lyle, Ltd., and The Huskisson Transit Company.

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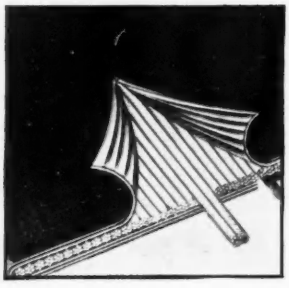

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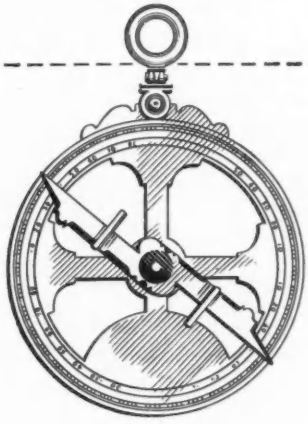

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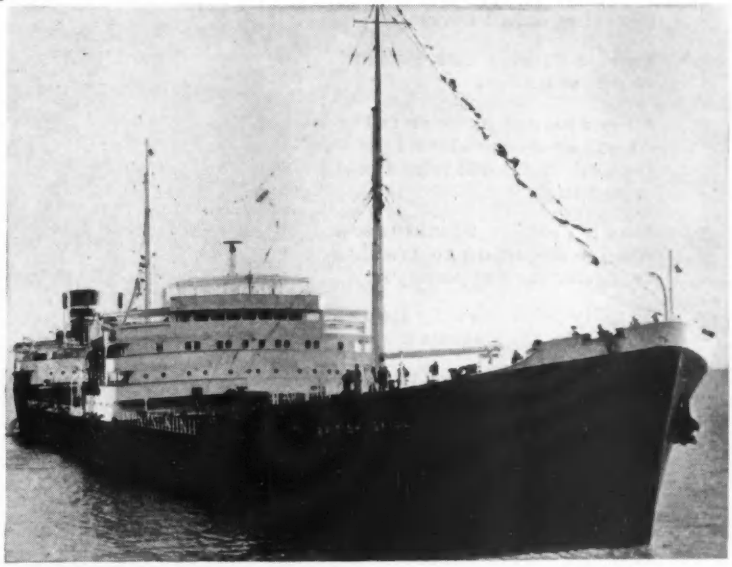

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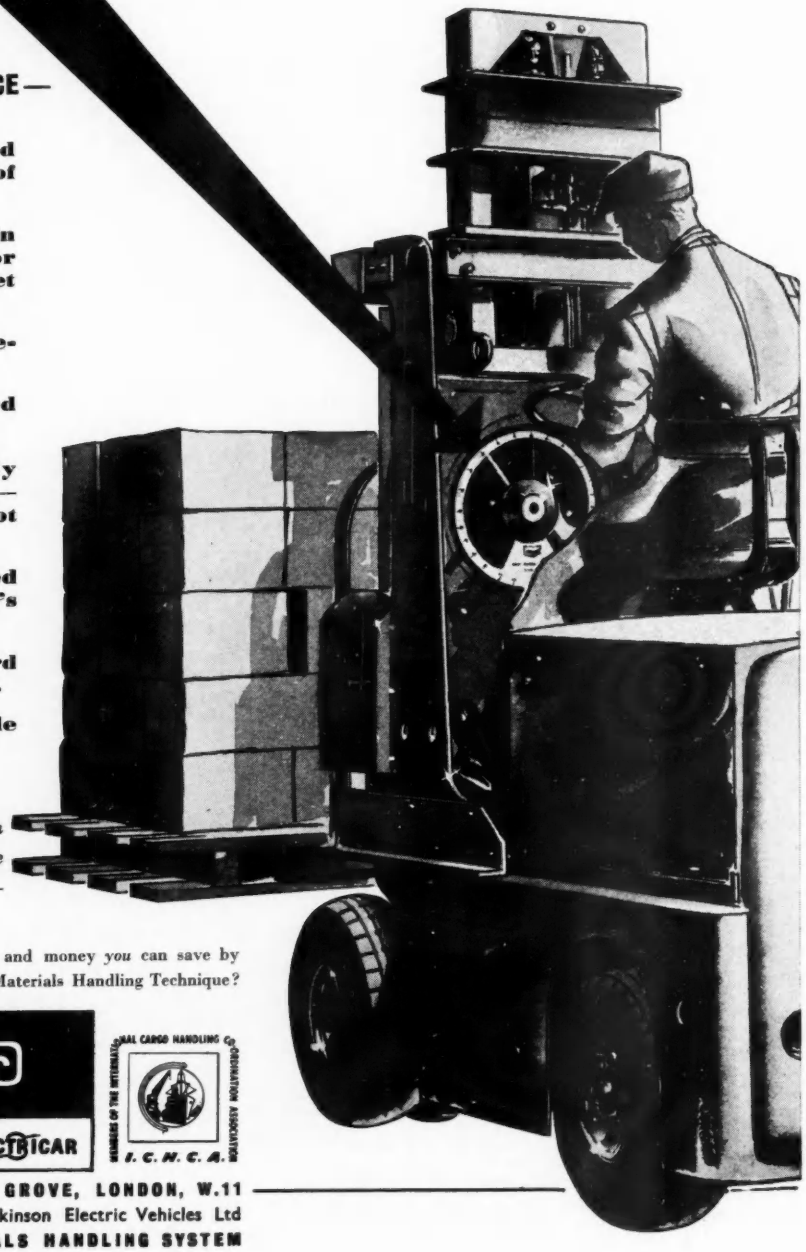

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Oscillations of the Sea and the Phenomenon of Range

Part 2. Ocean Waves and Sea Vibrations

By B. W. WILSON, M.Sc., C.E. (Illinois), A.M.I.C.E., Assoc.M.ASCE., A.M.(S.A.)I.C.E.

(*continued from page 45*)

THE findings of Part I of this series of articles establish that irregular coastlines fronting on the ocean are subject to the same general phenomenon as inland lakes, and have their own seiches. But besides the regular lake seiches, Forel recognised more rapid oscillations with periods of only a few minutes which he called " vibrations." These he noticed arose when the wind blew from certain quarters, but whereas the visible wind waves had periods of only 4 to 5 seconds, the vibrations usually had periods of from 45 seconds to 4 minutes.

Forel came to the conclusion eventually that these vibrations were longitudinal seiches of high nodality; higher harmonics, in other words, of the more fundamental seiches, but Professor Chrystal, discussing this question, points out that all the evidence is against such an hypothesis. Chrystal found the same embroidery of vibrations on his limnograms for Loch Earn with periods most frequently of the order of 1.5 minutes. It was never observed unless there had been sufficient wind to generate ordinary surface waves, and it subsided with the disappearance of these waves; further it was usually a feature of the leeward or receiving end of the lake but absent at the windward end. In most cases too the microbarograms showed what Chrystal calls " wind-blurring," suggestive of fluctuations of very short period, which in some cases seemed to coincide with the lake vibrations, but Chrystal was unable to establish any direct association with fluctuations of wind because of the condensed time scale on the anemograms. If the vibrations were, in fact, high-nodality seiches, then their phases at opposite sides of the lake must be the same, but by signalling he was able to disprove this.

Forel noticed that the steamers on the Lake of Geneva generated vibrations very similar to the wind's, and the embroidery from the latter, because of this, could only be studied at night when steamers were not plying to and fro. The remarkable thing about the steamer vibrations was that they preceded a vessel so that it was possible to be aware of its approach as much as half-an-hour before its final arrival at the observing station. This peculiarity of antecedent vibrations was noticed also by Chrystal in respect of the approach of a squall, and he likened the phenomenon to the well-known fact of a swell presaging a storm at sea.

Professor Chrystal reached no final conclusion on the enigma of the lake vibrations unless it was that changing wind pressure would generate trains of waves of differing wave-length, which as wave groups might account for some of the periods in the embroidery. Sir George Darwin, while expressing considerable surprise at the fact that waves of a length between crests of from ½ to 1 mile could be generated by wind and steamers, was disposed to explain their existence on the basis of the analogy of the waves created by a stone falling into water[1]. Waves so generated are of all wave-lengths, but it is the longer ones which out-distance and precede the shorter ones.

In the same way that Forel, Chrystal and Darwin saw fit to differentiate between the true lake-seiches and what they called " vibrations," so we may divine a distinction between the coastal seiches and the smaller vibrations of the sea. These latter also give rise to a dense embroidery on the marigrams traced by harbour tide-gauges and have periodicities in general much shorter than the coastal seiches. Their existence, it would seem from the conclusions drawn in respect of lake-vibrations, is to be attributed to ocean waves generated by wind or pressure disturbances. We are therefore led to enquire further into the nature of ocean waves with the object of defining the connection more closely.

Types of Waves.

In his great classic study of waves, Scott Russell[2] recognised four types, which he classified in orders. Only waves of the first two orders concern us here: these are waves of translation and waves of oscillation, the distinction lying in the fact that there is mass-transport of water in the first type, which is solitary, while there is only elliptical motion of water particles in the second, which is inclined to occur in groups. The solitary wave has a crest and no trough and derives from the sudden addition or displacement of a mass of water in an otherwise tranquil body of water. Waves of oscillation (representing wind waves, ocean swell and even tidal waves) tend to assume the properties of waves of translation in shoaling water where they are caused to break or accumulate in the form of tidal bores*. The solitary wave of translation may be regarded as an extreme case of oscillatory waves in which the wave-length is very great compared with the depth, with the result that the crests are virtually independent of each other. Boussinesq and Raleigh both independently succeeded in applying hydrodynamical theory to this type of wave and derived the formula for its velocity which agreed precisely with the empirical formula devised by Scott Russell to fit his experimental results. Here was a particularly beautiful example of concordance between theory and experiment, and it is the more remarkable in that Airy had previously claimed that his results, by approximate theory, fitted the observations, a contention which was vehemently refuted by Scott Russell in the interests of scientific accuracy.

Although the rollers and ocean-swell off the Cape of Good Hope, which are typical of ocean waves, were classed as waves of translation by Scott Russell himself, we shall nevertheless pay particular attention to waves of oscillation, bearing in mind the observation already made that waves of translation are a limiting type of oscillatory waves.

Waves of oscillation, having a finite amplitude which is commensurable with the wave length, have a surface profile which is very nearly trochoidal[3]. This was first demonstrated theoretically by Stokes and has since been verified experimentally by observation and measurement of natural and artificial waves.[4] In this form the wave crests are sharper and the troughs flatter than in a pure sinusoidal profile, and it is probable that very high waves in deep water approximate to this shape. When the amplitude is small compared with the wave-length the profile becomes sinusoidal and this is the form most characteristic of long waves and ocean-swell. Comprehensive experiments with electrical recording equipment off the coast of Algiers[5] have verified that the profile of heavy swells is in fact very closely sinusoidal.

Oscillatory waves have been shown, both in theory and practice, to give rise to a small momentum of the wave particles which is progressive in the direction of wave travel[6].

Properties of Oscillatory Waves.

(Note: In the following discussion the author refers to the amplitude of waves (A), by which is meant the vertical distance from crest to mean still water level, as distinct from wave height; (H), the distance from crest to trough. H therefore equals 2A.—Ed.).

On the basis that the amplitude, A, of an ordinary oscillatory wave is small compared with the wave-length, λ, and the depth, d, of water, the canonical equation for the velocity of the wave is

$$c = \sqrt{\frac{g\lambda}{2\pi} \tanh \frac{2\pi d}{\lambda}} \qquad (1)$$

where g is the acceleration due to gravity. This presupposes that the waves are large enough to render surface tension of small

*Scott Russell himself made this observation: Cf. also Bigelow and Edmondson, " Wind Waves at Sea. Breakers and Surf " (Washington), 1947, p. 115; Brown, " The Flow of Water in Tidal Canals ", Trans. Am. Soc. C.E., Vol. 96, 1932, pp. 749-834.

Oscillations of the Sea and the Phenomenon of Range—continued

account, and that the motion is irrotational, without vorticity. Although turbulence is set up by flow of water across rough boundary surfaces, the low viscosity of water prevents rapid permeation and this factor is not ordinarily important in wave motion.

It is interesting to record, in passing, that equation (1) was presaged by Newton in 1686, when he concluded that:

" The velocity of waves varies as the square root of breadths "[7].

By writing $$\sigma = \frac{2\pi}{\tau} \quad (2)$$

and $$k = \frac{2\pi}{\lambda} \quad (3)$$

where τ is the period of the wave, equation (1) can be transformed to:

$$c = \sqrt{gd\left(\frac{\tanh kd}{kd}\right)} \quad (4)$$

Further, by noting that $\lambda = c\tau$ (5)

equation (1) may also be expressed in the form:

$$c = \frac{g}{\sigma}\tanh\left(\frac{\sigma d}{c}\right) \quad (6)$$

From (1) and (4) it will be obvious that when the hyperbolic tangent approximates to unity, the velocity is given by

$$c = \sqrt{\frac{g}{k}} = \sqrt{\frac{g\lambda}{2\pi}} \quad (7)$$

This applies to all waves whose wave-length is less than twice the depth of water. On the other hand, all waves whose wave-length is large compared with the depth, are propagated with a speed approximating to $c = \sqrt{gd}$ (8)

since the hyperbolic tangent tends to the value kd when d/λ is small.

If the progression of the wave in a constant depth of water be referred to a co-ordinate system XOZ whose origin O lies in the plane of the undisturbed surface of the water and whose OX axis is horizontal and positive in the direction of wave travel, the OZ axis being vertical and positive upwards, the equations for the component displacements (ξ, η) of any particular water particle (x,z) may be written

$$\left.\begin{aligned} &\text{(i)}\quad \xi = A\frac{\cosh k(z+d)}{\sinh kd}\cos(kx - \sigma t) \quad \text{(horizontally,)} \\ &\text{(ii)}\quad \eta = A\frac{\sinh k(z+d)}{\sinh kd}\sin(kx - \sigma t) \quad \text{(vertically),} \end{aligned}\right\} \quad (9)$$

where t is the elapsed time. Equations (9) are the parameters of the elliptic-harmonic orbit of the water particle, its periodicity being the same as that of the wave.

From equation (9)—(i) we see that the hyperbolic factor varies from 1/tanh kd at the surface ($z=0$) to 1/sinh kd at the bottom ($z = -d$). For long waves where λ is large compared with d, the hyperbolic sine and tangent are of the same order, and the horizontal movement of water is thus sensibly the same at all depths. The vertical movement, of course, varies from 2A at the surface to zero at the bottom. The ratio of bottom to surface horizontal movement, in the general case, is 1/cosh kd.

The wave-lengths, speeds and movements of oscillatory waves of various periodicities may be examined with benefit on a diagram of the form of Fig. 3. This was derived from equation (6), in which the value of C occurring in the hyperbolic tangent was estimated beforehand from a judicious use of equations (7) and (8). By successive approximations in this way the true values of C could be found. Consider, for example, a wave of 15 seconds periodicity advancing from deep water (d= 10,000-ft., say), towards a shelving coast. Fig. 3 shows that its wave-length and speed remain constant at about 1,140-ft. and 80-ft./sec. respectively until the water depth has reduced to 1,000-ft. In all this time the water particles at the sea bottom have hardly been disturbed, but as the water shoals further, the wave-length of the wave becomes contracted and its advance progressively slower, while the oscillatory movement is communicated more and more to the water particles on the sea-bed. By the time the wave has entered 15-ft. of water the horizontal movement on the bottom is theoretically 95 per cent. of the surface movement; wave-length is 320-ft., and velocity only 22 ft./sec., or 15 m.p.h.

The shaded bands on the diagram indicate the progressive increase in oscillatory movement at the sea-bottom which is defined by the increasing ratios of the diagonal dash-dot lines as shallow water is approached. In the hatched portion of the diagram the movement is virtually solid from surface to bottom. Here it will be noticed the periodicity lines are all almost parallel and conform to equation (8) for long waves. The unshaded portion of the diagram conforms to equation (7) for short waves in deep water. In the transition zone between the dash-dot diagonal lines, neither of equations (7) or (8) is accurate and the properties of the wave must be evaluated from the full equation (1), (4) or (6).

In comparison with these small-amplitude waves, trochoidal waves of finite amplitude progress with a velocity approximating to

$$c = \sqrt{\frac{g}{k}(1 + k^2A^2)} \quad (10)$$

This, in point of fact, is very little different from equation (7), even for waves of appreciable amplitude. Consider, for instance, 10 second waves, for which, in deep water, the wave-length is about 500-ft. (Fig. 3). If these waves have a height, 2A, of 50-ft., which by ordinary standards is very considerable, the influence of the term (kA^2) will still only be such as to increase the value of the velocity, as given by equation (7), by about 5 per cent. For 15 and 20 second waves, which are the only other types which ever attain to great heights, " tidal " (" tsunami ") waves excepted, the differences are smaller still. The effect of limited depth upon these trochoidal waves does not appear to invalidate the conclusion that the chart of Fig. 3 will apply without very serious error even to waves of fair amplitude.

Scott Russell's solitary wave of translation has a velocity of

$$c = \sqrt{g(d + A)} \quad (11)$$

which, but for the inclusion of the amplitude, is the same as equation (8). This formula really only begins to apply after a wave has broken or been retarded to the point of an accumulation in a shallow estuary[8]. Most long waves of oscillation such as are depicted in the shaded zone of Fig. 3, are waves of translation in the particular sense that they constitute a solid mass-movement of water over the sea-bed, but, unlike the solitary wave, the motion is reversible, as indeed it must be to produce a seiche-phenomenon. Long waves in general tend to have much smaller amplitudes than the visible wind-waves and swell, and the assumption that amplitudes be small in comparison with wave-length and depth is really more satisfactorily observed with them than with short waves of the latter type. Our general conclusion therefore is that Fig. 3 will apply with reasonable approximation to all the types of waves with which we are likely to be concerned, regardless of their magnitudes in height.

Group-Velocity of Waves.

The wave-velocities of Fig. 3 apply to individual waves, but when groups of waves of slightly different periodicities are propagated in the same direction they interfere to produce the phenomenon of " beats " in which the resultant waves travel in separated groups whose velocity as a whole is less than the velocity of the individual waves comprising them. This phenomenon appears to have been observed first by Scott Russell, who recorded:

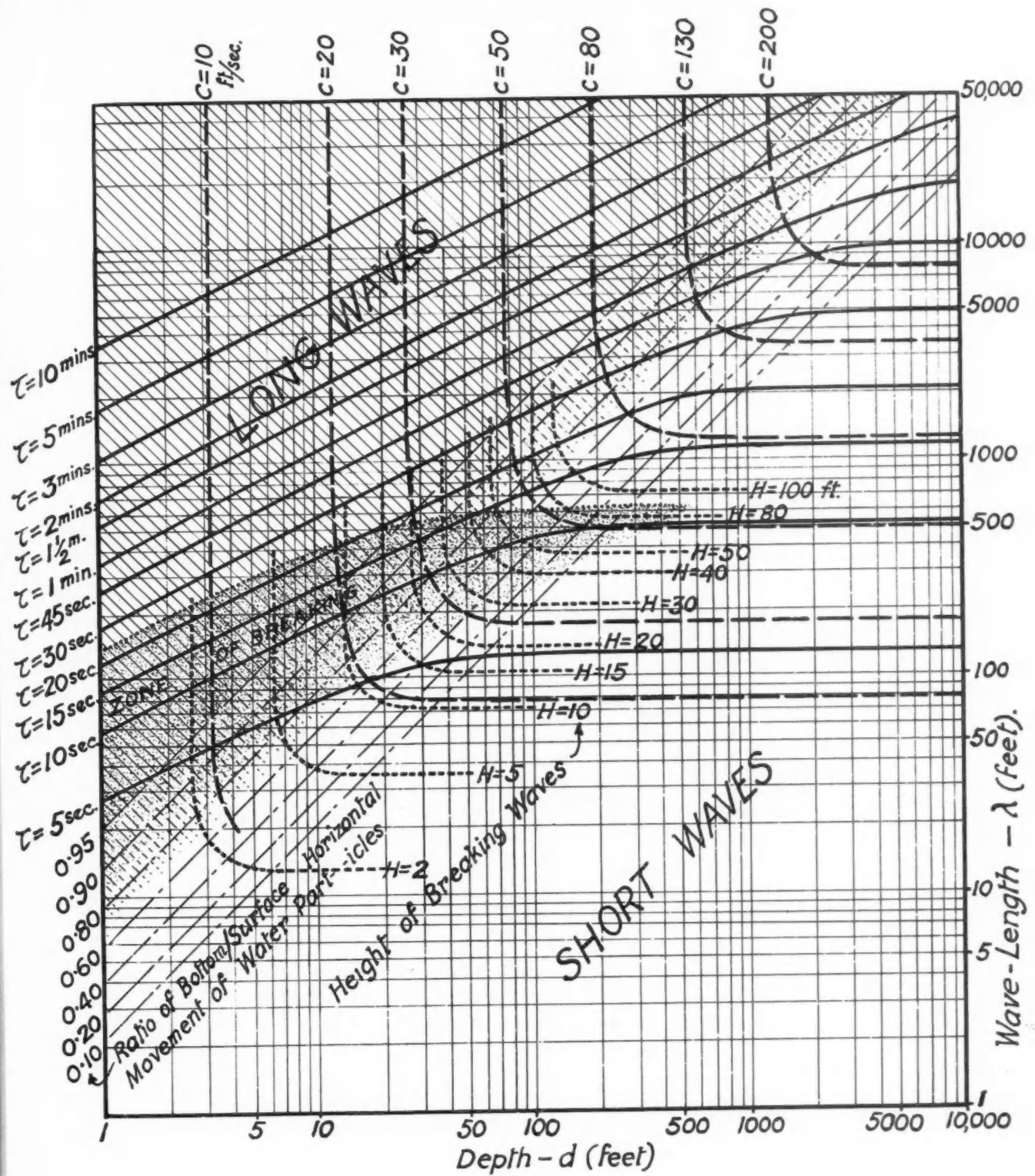
" . . . the velocity of wave *transmission* may be very different from the velocity of wave *propagation*."

He describes how a particular wave is seen to advance through a group, only to disappear in the front while its place is taken by another wave that has grown in size from the rear.

Stokes showed that this group velocity, U, in terms of the wave-length of the waves comprising the group and the depth of water, may be represented by the formula:

$$U = \tfrac{1}{2}c\left(1 + \frac{2kd}{\sinh 2kd}\right) \quad (12)$$

When the depth is great compared with the wave-length, as with short waves falling in the unshaded zone of Fig. 3, the group-velocity, U, is half the wave velocity, but when the depth is relatively small, U has the same value as c. For all long waves falling within the deeply shaded band to the left of the 0.95 diagonal line



Relationships between Periodicity, τ, Velocity, c, Horizontal Movement, Wave-Length, λ, Depth, d, & Breaker Height, H, for Waves; based on $C=\sqrt{\frac{g\lambda}{2\pi}\tanh\frac{2\pi d}{\lambda}}$ B.W.W.

& Michell, McCowan Criteria for Wave Stability, respectively $\frac{H}{\lambda}=\frac{1}{7}$; $\frac{H}{d}=0{\cdot}78$.

Fig. 3.

Oscillations of the Sea and the Phenomenon of Range—continued

(Fig. 3), the group-velocity will be the same as the wave-velocity, since d/λ in this zone will everywhere be less than 1/20 (the value along the diagonal), making $U = 0.97c$ or better.

It is clear from this that in a mixed assortment of waves originating from a disturbance in deep water, the long waves will outstrip the short ones owing to their far greater group velocities. Short waves, while proceeding slowly at first as groups in relation to their individual waves, will gather speed relatively as they progress towards shallower water, until in the final stages, as Fig. 3 shows, when they enter the deeply shaded band, their velocities will be equal. Since even 5 second waves cut the shaded band of Fig. 3, it follows that we should look in vain for the phenomenon of waves, rising from the rear of a group, advancing through it and dying at the front, in ordinary sea-waves close inshore.

Wind-Waves and Swell.

Helmholtz showed that waves tend to be generated at the surface of discontinuity between two fluid media of different densities, travelling at different velocities across each other[9]. Such conditions prevail on the surface of the sea where the wind generates waves by traction across the interface between air and water.

Jeffreys[10], in investigating the relationship between wind and wave-velocities, concluded that the wind can only supply energy to the waves so long as their velocity is less than that of the wind. Since wind-velocities, even in hurricane-force, do not run much above 100 m.p.h., it follows from Fig. 3 that, in deep water, periodicities of ordinary wind-generated waves cannot much exceed about 20 seconds. This is confirmed by the many observations that have now been made on ocean-waves and swell. Vaughan Cornish[11], who spent a lifetime making scientific observations of waves in all parts of the world, never discovered visible waves above 22½ seconds in period: comparatively rarely too did he see waves of the order of 19 and 20 seconds. The longest period on record for a visible swell appears to be 26 seconds, experienced off the coast of England. For the most part visible waves and swell have been found to lie within the periodicity range of from 5 to 15 seconds with the emphasis between 7 and 9 seconds[12].

The heights to which wind-waves attain have been found to bear an approximate lineal relationship to the wind-speed, but length of fetch and duration of wind are also factors influencing the height. Thomas Stevenson[13] in 1850 made observations in the Firth of Forth and the Moray Firth, as well as on a fresh-water loch, in Scotland, and concluded that wave-height was proportional to the square root of the length of fetch. His formula, $2A = 1{\cdot}5\sqrt{f}$ for height in feet and fetch, f, in miles, is still currently accepted as an empirical rule for estimating wave-heights, and appears to agree with Cornish's observations.

The general consensus of opinion now is that the vast majority of all waves in all parts of the oceans are not above 12-ft. in height and that the frequency of greater heights than this is only about 20 per cent. As an indication of the relationships likely to prevail between wind-speed and wave-proportions, we reproduce below the table of Cornish, generalising his observations:

Table I : Properties of Wind-Waves at Sea

Wind Speed mph.	Wave Speed mph. c	Period secs. τ	Wave-length feet λ	Height feet $2A$	Length-height Ratio
(1)	(2) = 0.8(1)	(3) = $\frac{2}{5}$ (2)	(4) = $\frac{4{\cdot}1}{8}$ (3)	(5) = 0.7(1)	(6)
31	25	7	250	22	11.6
35	28	8	330	24½	13.3
42	33½	9½	470	29½	16.0
50	40	11½	670	35	19.0
59	47	13½	930	41½	22.6
68	54½	15½	1,230	47½	25.9

The maximum heights to which waves attain, before becoming unstable and breaking, depends on the nature of the waves. McCowan's theory[14] for long waves indicates that breaker height, H_b, and depth at breaking are related by

$$H_b = 0{\cdot}78d. \qquad (13)$$

a result which has been verified experimentally by numerous observers[15]. Short waves in deep water, on the other hand, according to the investigations of Stokes and Mitchell reach a condition of instability when

$$H_{max} = 0{\cdot}143\lambda. \qquad (14)$$

This criterion has apparently not yet been positively verified by experiment but it has certainly not been disproved and it is currently accepted as being correct. Reid[16], by representing these limiting conditions together in a plot of the parameters H_b/d and d/τ^2, has indicated the probable trend of the relationship in the intermediate transition zone which must link the McCowan and Michell criteria. This empirical trend has permitted of the breaker height contours being drawn in Fig. 3 (short dash lines) within the region where waves are intermediate between long and short.

The interpretation of breaker heights from Fig. 3 may best be demonstrated by an example. It is clear, for instance, that 5 second waves in deep water cannot attain a height much greater than 18 to 19-ft. without becoming unstable and breaking. Ten second waves, on the other hand, can attain to a height of just over 70-ft. before reaching instability in deep water. Assuming, however, that a 10 second wave has a height in deep water of only 30-ft., Fig. 3 shows that it could penetrate shoreward to a depth of about 41-ft. before breaking, its velocity at that stage being about 32 ft./sec., its wave length 320-ft., and its particle movements at bed bottom being some 75 per cent. of those at the wave crest. Had the 10 second wave had a height of only 5-ft. it would have travelled into a depth of 6.2-ft. before breaking. A 15 or 20 second wave of the same height, it will be seen, would also break in a depth of 6.2-ft. of water, as would a seismic sea wave of 10 minutes period having this height.

On the basis that purely wind-generated waves cannot attain to periods much in excess of 25 seconds and that the spectrum of wave heights will show a tapering off of amplitude as this limiting periodicity is approached, it is possible to define an empirical zone of breaking in Fig. 3, shown by the stippled shading, outside of which waves will generally have such low amplitudes as to be incapable of full breaking. In large measure, therefore, the upper half of Fig. 3, above the zone of breaking, embraces all long waves impinging on a coastline which will retain a considerable portion of their energy for propagation in wave reflections.

In recent years great attention has been concentrated on the subject of ocean-waves and swells[17]. During the last war the forecasting of swells was an important prelude to invasion-landings and the study naturally received the full support of military exigency[18]. On the whole the findings of these investigations substantiate the information and deductions already presented, but they showed that swells had unsuspected powers of propagation over incredibly large distances. By means of sensitive recording apparatus and new analytical techniques[19] swells arriving on the coasts of England have been traced back to their origins in storm-centres as much as 6,000 miles away in the South Atlantic. Similar correlations over equivalent distances have been made in respect of swells arriving on the western seaboard of the United States from the Pacific Ocean[20].

Once waves have escaped from a storm-centre where they have been under the domination of winds, they are propagated as smooth swells under the influence of gravity and friction only. The fact that swells are able to escape at all from their faster generating winds must, of course, be ascribed to the gradual dispersion of the winds outwards across concentric isobars of the depressions, which are usually the focal points of genesis for waves, as also to the slower speeds (20—35 m.p.h.) of progression of these storms in comparison with those of the winds within them and of the waves.

The warning which swells are able to give of the approach of storms is proverbial and in the British Isles they have been known for generations as "death waves." But in the South Atlantic where the islands of Ascension, St. Helena and Tristran da Cunha rise sheer from great depths of ocean, the swells reach their most impressive proportions. Webster's account of them in 1829 is classical[21]:

> "One of the most interesting phenomena at Ascension are the rollers; in other words, a heavy swell producing a high surf on the leeward shores of the island, occurring without any apparent cause. All is tranquil in the distance, the sea-breeze scarcely ripples the surface of the water, when a high swelling wave is suddenly observed rolling towards the island. At first it appears to move slowly forward, till at length it reaches the beach, where

Oscillations of the Sea and the Phenomenon of Range—continued

it bursts with tremendous fury."

An interesting example of the extent to which swell can be the precursor of a storm concerns the Bermudas hurricane of 1839 (Stevenson loc. cit). The swell was observed on the southern shores of the island three days before the arrival of the hurricane, and increased in intensity steadily with the approach of the cyclone, until the latter burst upon the islands.

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(to be continued)

East African Port Facilities

Improvements Proposed for Mombasa

On many occasions during recent years, protracted delays have been experienced by large numbers of vessels trading to East African ports, especially Mombasa. The subject has frequently been referred to in this Journal, and while reports have been received from time to time that the position had become easier, the improvement did not last long and was, moreover, partly the result of diversion of shipping, limitation of tonnage and other circumstances.

All the difficulties experienced at the Port of Mombasa cannot be ascribed to lack of foresight and planning on the part of the East African Railways and Harbours Administration. The rapidly increasing post-war traffic imposed a considerable strain upon both docks and railways whose facilities were depleted by war conditions. In 1951, congestion reached a climax at the port due to an accumulation of East African cargoes arriving simultaneously from a number of United Kingdom ports, where they had been waiting to be loaded on ships which had been temporarily diverted to other duties.

The Administration had long been aware of the need for additional facilities at Mombasa, but the principal difficulties lay in providing the necessary finance and obtaining plant and materials. Again new works at Dar-es-Salaam and a new port at Mtwara were given priority by the British Government in connection with the ground nut scheme, which left very little financial aid for the Port of Mombasa. The problem of ship delays, in its overall conception, as has often been stressed editorially in this Journal, was clearly one that could only be finally solved by a long-term programme of port development and increased transport facilities between the East African coast and inland centres.

Arising from continued complaints about the serious delays to shipping, the East African High Commission, in July, 1952, appointed a Committee of Enquiry to consider (1) proposals for improving transport facilities in East Africa, with particular reference to Mombasa, and (2) to investigate and report on the reasons for delays in clearance of goods consigned through that port.

As a result of their investigations, the Committee, under the chairmanship of Mr. R. G. Norton, C.M.G., O.B.E., submitted a Report in February last. The 33 recommendations and 10 appendices contained in it are almost wholly confined to the Port of Mombasa. They reflect, by their number as well as by their nature, at least the formidable problem of effecting complete efficiency of transport and of ports in East Africa, and they cover almost every aspect of administration and operation.

The presentation of the Norton Report speedily evoked on the part of the East African Railways and Harbours Administration a series of comments and memoranda on the Committee's Report, prepared by the General Manager, Mr. A. Dalton, for the consideration of the Transport Advisory Council, and later by the High Commission of East Africa.

The Railway Administration's comments on the Committee's findings made almost as massive a document as the original report, and emphasised that a number of the recommendations left much to be desired. Particular exception was taken to the failure of the Committee to acknowledge that many of the measures which it suggested were already in hand or under consideration before the Report was published. This did the Administration less than justice as in 16 or 17 instances the recommendations were based, without acknowledgment, on projects for improving port capacity and plans for future development, which were reported to the Committee by the Administration, in the course of the Enquiry.

Certain recommendations were unacceptable to the Administration, except with reservations, and it disagreed with the Committee's criticism of its past planning and financial arrangements for the improvement of Mombasa. It was also to be expected that the Administration would register strong disagreement with the Committee's views that, in efforts to build up an efficient transport system in East Africa steps should be taken to divide the railways and its ports into separate managements.

The Committee's Report and the Administration's replies were then considered by the Transport Advisory Council and the latest stage in the matter was reached by the recent publication of the Decisions of the High Commission which are largely based on the views put forward by the Advisory Council.

The majority of the Recommendations and Decisions are concerned with matters of development, administration and operation involving questions of a purely local character. There are, however, a number of items which are perhaps controversial, but which should prove of interest to a far wider field of readers.

The Report embodying the advice of the Transport Advisory Council summarised the Enquiry Committee's Recommendations into five main groups.

East African Port Facilities—(continued)

GROUP I.—Recommendations which are Confirmation or Advocacy of Action taken, or of Schemes under Consideration by the East African Railways and Harbours Administration.

The Paper states . . . " The High Commission, while realising that this group of Recommendations introduces no new proposals, nevertheless appreciates the Committee's underlining of the vital importance of the various works and agrees that the utmost possible should be done within the limits of the financial and physical resources to expedite completion or realisation of the various proposals, subject to the practical considerations mentioned in the comments of the Transport Advisory Council."

One of the principal Recommendations in this Group is No. 4.

(4) **Mechanisation of the Port.** The Committee's remarks may be abbreviated as follows: " It appears that given suitable conditions and despite loss of space caused by the lanes which have to be left for the trucks in the sheds, the use of Fork Lift trucks and Pallets can certainly speed up movement through the sheds and can increase storage density in them by possibly 30 per cent. Moreover, mechanical handling notably decreases damage to and pilfering of cargo. The development of East Africa must lead to an increased volume of trade and this will necessitate the introduction of mechanised handling as an essential factor in the quick and efficient movement of merchandise. We therefore **recommend** that intensive experiments be continued with a view to increasing as quickly as possible the mechanisation of the port."

The decision of the High Commission endorsed the continuance of the experiments commenced by the Administration, subject to the Transport Advisory Council's advice that " a degree of caution is necessary and that mechanisation is but one of the measures to be undertaken to improve port capacity."

Another matter of considerable importance is that of Lighterage, which is dealt with in the Committee's Recommendation No. 5, which suggests a full complement of lighters to be supplied to the port at the earliest opportunity and also embraces consideration of local problems.

As there appears to be some disputation regarding the use and provision of lighterage facilities at ports, a short summary of the Committee's Recommendations is appended together with excerpts from the Administration's Comments followed by the Decisions of the High Commission and our own remarks.

(5) **Lighterage Facilities.** " We are of the opinion that the full use of lighterage facilities would make an important contribution to the fluidity of the port in both the short and long term. Properly used, they provide an unusually flexible instrument as they can be employed for loading and unloading ships in the stream, for loading and unloading ships at the deep-water berths, for use as auxiliaries to the shore cranes in conjunction with ships' derricks and for temporary storage, particularly when it is desired to turn a ship round without delay. . . .

It is a *sine qua non* at *all* ports that adequate provision of lighterage is an essential ancillary to deep-water berths and to efficient port working. We consider that it is most important that the full complement of lighters be supplied to the Port of Mombasa at the very earliest possible opportunity and **recommend** that the work at present in progress to extend the lighterage wharves should be pressed on and given a high priority. Although we were informed that the steep gradient of the railway line from Mbaraki militated against its usefulness, we recommend that further expert study should be given to the use of this wharf, possibly with temporary hangar storage, for suitable types of import and/or export cargoes. With the port expanding towards the mainland, we **recommend** that consideration should be given to the siting of an auxiliary lighterage wharf at the Kipevu end of the port."

The following is the gist of certain remarks contained in the Comments of the Administration, pertinent to the general question of lighterage.

As a general rule, deep-water berths may be considered as being cheaper to operate, of greater capacity per lineal foot and more efficient than lighterage wharves. Allusion was made to the September, 1951, issue of " The Dock and Harbour Authority." The article referred to was a paper by R. D. Gwyther, M.C., M.Sc., M.I.C.E., presented to the Conference on Civil Engineering Problems in the Colonies, held in London in July, 1950, and other points brought forward in the Comments by Mr. Dalton were that the use of lighters in colonial ports is largely being reduced owing to the increased costs of labour, increased handling and greater liability to breakage and pilferage involving higher insurance costs. Mr. Dalton also points out that the extension of the Lighterage Wharf at Mombasa was accepted by the Administration only as a quick palliative for port congestion and had the time factor not been of such a pressing urgency, it is almost certain that an additional deep-water berth would have been built instead.

The Administration's Comments also refer to the Committee's statement that adequate provision of lighterage is an essential ancillary to deep-water berths. They proceed to show that while large numbers of deep-water ports are without lighterage facilities altogether, those ports that have them depend upon lighterage from necessity rather than from choice.

The High Commission appears to be somewhat guarded in its Decisions upon the lighterage question, stating that, "The lighterage position at all ports is under continual review by the Harbours Committee and the Members of the Committee are entirely satisfied that the Management's proposals, including recent proposals for further accretions to the lighter fleet, are now adequate to meet foreseeable requirements."

In the light of the modern tendency to provide deep-water berths both at new ports and at others hitherto dependent upon lighterage facilities, there is considerable doubt whether the latter facilities are a *sine qua non* at *all* ports as the Enquiry Commitee claims. In the case of many colonial ports existing lighterage practice is probably a survival from the small beginnings of the port when they may have been merely roadsteads and trade was not in sufficient quantity to justify the construction of costly deep-water wharves. The new tendency is therefore significant, but it must not be forgotten that vessels lying at deep-water berths can still be unloaded or loaded on the water side with the aid of lighters and the ships' derricks. This effects a considerable saving in the time of discharge of a vessel and is a practice carried out in the docks of the Port of London Authority, where large proportions of imported foodstuffs and raw materials are consigned to privately owned riverside wharves where the water is insufficient for deep drafted vessels.

Similar conditions prevail at Calcutta, Singapore, Rangoon and elsewhere, and in these instances lighterage may be regarded more as a distributing agency than as a primary means of discharging or loading vessels. This is particularly so in the cases of Amsterdam and Hamburg, where the barges are specially designed to carry hundreds of tons of goods for long distances inland.

To quote another example of lighterage practiced as a means of distribution, in the Port of New York the majority of deep-water piers are situated on the Manhattan side of the waterway while several of the great railroad terminals to the interior are on the New Jersey side. Thus an extensive lighterage service has developed, which is considered to be an important factor in ship turn-round time.

(6) **Wagon Turn-round.** " The Committee considered that improvement could be secured by an increased number of port railway trucks and road vehicles and by increased storage facilities upcountry." The trucks used in the docks are units of rolling stock condemned for main line service.

The High Commission endorsed the statements of the Administration that orders for great numbers of vehicles have been placed for port use and road traffic and that delivery is awaited.

(11) **Warehousing of Export Produce.** " As a legacy of pre-war practice, the Administration accept in the transit sheds bulk consignments of produce, such as coffee and cotton, for warehousing until there is a shipping opportunity. We consider that in principle this is an undesirable arrangement which leads to congestion. Although for practical reasons, it is not possible at the present time to abolish it completely, we **recommend** that quantities be kept to a minimum until such time as separate warehouse accommodation can be provided.

(13) **Transit Sheds** should only be used for the temporary accommodation of import cargo for a specified period and for export cargoes only when called forward for shipment.

(14) **Uncleared Import Cargoes.** Import cargo which cannot be cleared promptly by the consignees for whatever reason should be removed to uncleared cargo sheds by the Administration at the consignee's expense.

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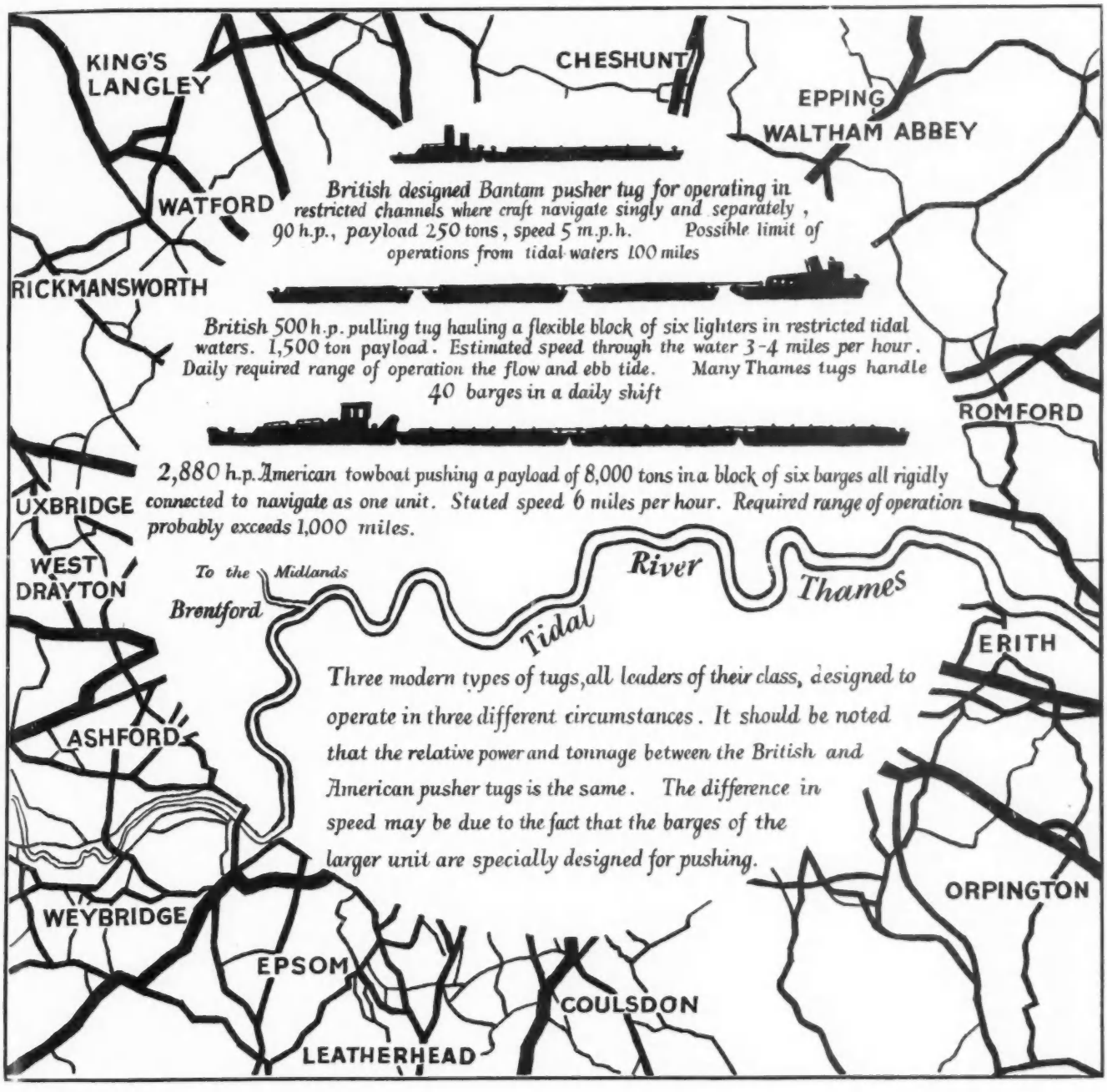
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East African Port Facilities—(continued)

(15) **New Sheds.** We consider it is of first importance to expedite as far as possible the building of new sheds and until this has been done there can be no amelioration of the position.

(16) **Free Storage Period.** In view of the steps recently approved for speeding up Customs procedure, we **recommend** that in the present circumstances the present free period should be reduced from six to five days, which would help to relieve congestion in the sheds."

With the above Recommendations of the Committee the High Commission was in agreement accepting the view as to (11), that the storage of exports in transit sheds should be kept to a minimum, but realising that this involves the necessity for adequate warehousing capacity, sited convenient to the plot, to accommodate export cargo which has been accumulated for shipment and waiting to be called forward.

The question of ways and means of providing such warehousing, in all its aspects had been under active consideration by the Transport Advisory Council for some time.

Recommendations Nos. 13, 14, 15 and 16 were also endorsed by the High Commission, which said that the eventual use of the four new sheds at the back of the port, approved some time ago with the object of easing transit shed congestion, will go a long way towards implementing the policy of utilisation of transit sheds only for temporary storage.

GROUP II.—Recommendations which were Stated to be Unacceptable to the East African Railways and Harbours Administration except with Reservations.

The six items in this Group are all concerned with local matters and are hardly of general interest. However, it may be mentioned that the most important proposal was the construction of a deep-water quay. This was referred back to the Transport Advisory Council Harbours Committee, for further consideration.

GROUP III.—Recommendations of a General Nature.

The most important recommendation in this Group was that devoted to Planning:

(31) **Necessity for Advance Planning in Harbour Development.** The Committee had been critical of the Administration's planning and financial policy and emphasised that " The secret of harbour development is to look ahead; even though the extension of the port area and the construction of new berths, etc., may not have been apparently necessary at the end of the war, we suggest that a survey of the area and plans for future development should have been prepared well in advance of the requirements of a developing territory. As it is, the survey for the extension of the lighterage wharf is still taking place and has not been completed at the time of writing. Final plans for the siting of the third new berth have not yet been made."

The following is an excerpt from the Committee's Report " Notwithstanding the heavy commitments of the railway elsewhere and the rising prices which diminished the value of the authorised loans, the meagreness of the sums allocated to the Port of Mombasa appears remarkable, but it becomes less surprising in view of the fact that, when the £23 million loan was negotiated with the Home Government (1948-1949), no comprehensive long term plans for the port had yet, so far as we can ascertain, been approved. The detailed scheme on which an application for funds for this purpose would have to have been based had not indeed at that time, been prepared."

The Administration naturally were at great pains to refute the allegations made by the Committee of Enquiry and brought forward many arguments and facts in support of their conduct of affairs.

While these matters are largely of domestic interest only, in fairness it must be said that the High Commission, to a great extent, accepted the statements of the Administration, and the following are some relevant excerpts from the Commission's decisions:—

" It may be accepted as axiomatic that it is necessary to look ahead in planning development, but to look ahead, in the sense used by the Committee of Enquiry, presupposes that future events are susceptible to close evaluation. This has not been possible over the past few years, during which the volume of traffic passing through Mombasa port has exceeded all expectations."

The High Commission was advised by the Transport Advisory Council that the broad plan of development of the Port of Mombasa had been in existence for many years. As to whether earlier action could and should have been taken by the Railways and Harbours Administration opinion was divided.

The Council as a whole realised, however, " that it is now of doubtful benefit to assess what should or could have been done in 1948 and it considered it enough to conclude that in the light of the very steep rise in traffic which followed immediately on the post-war boom, it is unfortunate that earlier steps were not taken to provide additional berths at Mombasa. The Council had, however, made clear its view that, for the reasons given (governing financial stringency etc.), this should not be regarded as a criticism of the Railways and Harbours Administration, which does not in any case bear the final responsibility, particularly where important matters of financial policy are involved." The High Commission accepted this view.

The Commission finalised their remarks on this Recommendation by saying that " while recognising that planning must be a continuing process, it is also well aware of the fact that finance has been and must be the governing factor in limiting development."

GROUP IV.—Organisation.

By far the most controversial Recommendations put forward by the Committee of Enquiry were those concerned with the management of the Railways and Ports. As the question is one of considerable interest in its broad conception various arguments and facts of special relevance, are given at some length, together with excerpts from the decisions of the High Commission and our own comments.

The Committee's first Recommendation is:

(32) **Appointment of General Manager, East African Ports and Harbours.**

" The development of East African ports in the last quarter of a century, coupled with the amalgamation of the East African Railways, has created a situation which has outmoded the idea of conducting the operation of ports as an ancillary service to the permanent way. We therefore consider it necessary to reorient the conception of port and railway control. We disagree with the statement issued after the meeting of the High Commission in November last to the effect that the separation of the management of the East African ports from the management of the railways would be a retrograde step. We **recommend** the appointment of a general manager of East African Ports and Harbours who would have equal status with the general manager of the railways and be directly responsible to the Commissioner for Transport. He would be assisted by an Advisory Committee which should be selected principally on the basis of knowledge and experience of port matters."

These views were based upon consideration of the working conditions of the present organisation, for example the question of priorities of requirements as between one port and another and track and rolling stock, the alleged extremely limited position of authority that the Superintendent of Ports and Lights holds in the present set up, and the large number of senior officers of wide railway experience compared with the experience which the administration can muster in the management of ports. Thus the administration was deemed to be in a much better position to make decisions on railway matters than on questions of port development. In this respect the Committee endorsed the recommendation contained in the Report of the Imperial Shipping Committee on the control of the Port of Mombasa which although published in 1926 was still relevant. The gist of this finding was to the effect that the two offices of railway manager and port manager should be clearly defined as separate, though as a temporary measure it might be expedient that the same man, if available, should hold both offices.

The Committee also noted the present tendency to give the largest possible measure of local autonomy to ports generally, and referred to the resolution recently passed by the Association of Chambers of Commerce of South Africa, urging the separation of

East African Port Facilities—(*continued*)

railways, airways and harbours, at present administered by the South African Railways, into three independent organisations with a deputy general manager, under the co-ordinating control of a general manager of transport.*

At the same time the Committee appreciated that no two ports and no two transport administrations are operating under identical conditions.

The Administration, in the General Manager's Comments strongly criticised the Committee's Recommendation, refuting several of the allegations in connection with present working conditions and bringing forward many cogent reasons and arguments for the maintenance of the *status quo*.

On the other hand many of the arguments can only be regarded as weak. For example a strong point is made of the fact that no comparisons can be made between one form of port organisation and another, which in any case was a reservation made by the Committee, and yet in other places in the general manager's comments, this is precisely what is done on a large scale.

In our view, one of the best arguments put forward for the non-separation of ports from railways is the reference to conditions in East Africa. The three main ports of the country are essentially rail ports, inasmuch as they are merely connecting links between the coast and a vast hinterland. In the case of Mombasa, 300 miles of arid desert separates it from the cultivated areas to which there is a steady uphill climb. Transport consists of 8 or 9 long-distance trains per day, each carrying only 350 to 400 tons of cargo per trip. It will be seen therefore that few other countries find it so essential to maintain the balance between port and railway capacity as East Africa.

The Administration states in its comments that the interests of the East African users are better secured by one control and also "The delicate balance between shipping owners' interests in the harbour and their predominant interest in the expeditious clearance of ships and the necessity to make the most economic use of all transportation facilities in the best interests of the whole East African economy can only be assured by unified management. The proposal to alter the organisation and to place more power in the hands of port users finds little favour in most quarters up-country, particularly in Uganda, where it is realised that in the struggle between the needs of up-country users and those of the port the latter would prevail."

This statement seems to need some clarification. For instance it is not at all clear how the ship owners, under the present arrangements, can voice their interests in the harbour. Also their endeavours to obtain a quick turn-round are in the interest of up-country users by reason of reduced freight charges.

The High Commission in its decision upon this all important matter, after examining every argument, stated as follows:

"In the result, the High Commission remains of the opinion that, in a newly-developing country such as East Africa, the existing organisation of the railway and port services is the most efficacious. The ports of East Africa serve a vast hinterland and, for all practical purposes, the export of the produce of that hinterland and the import of the materials for its development, must be dependent on rail transport. If East Africa is to be developed economically during the next decade, it is necessary to recognise that those factors make the ports and railways of East Africa essentially interdependent. This, and the very important consideration that financial and physical resources must be used to the best advantage, makes the closest possible integration of ports and railway services an inescapable need. . . . .

"The High Commission believe that there can be no doubt but that the achievements of the transport administration during the past few years of phenomenal traffic increases, with no corresponding increase in capacity, have been possible only with an organisation in which the ports and railways are under a single executive management. The High Commission cannot, therefore, accept the Inquiry Committee's proposal for the appointment of a general manager, East African Ports and Harbours. . . .

"The High Commission has, however, accepted the view of the Transport Advisory Council that the managerial organisation should be examined in the light of present-day conditions and likely future developments, and it has accordingly directed the Acting Commissioner for Transport to obtain specific recommendations from the Council and would wish the Council to give close consideration to the establishment of a post of deputy general manager and, amongst other possible measures, to the appointment of an assistant general manager (Harbours and Inland Waterways)."

Having regard to all the circumstances, the first decision seems to be in accordance with what one would expect at the present juncture. However, the proposed posts of deputy general manager and assistant general manager (Harbours and Inland Waterways) appears to indicate a realisation that the post of general manager, East African Railways and Harbours has been overloaded, and no doubt the additional officers will both concentrate their attention, under the overall control of the general manager himself, on Harbours and Inland Waterways. This is a step which has much to recommend it.

(33) **Commissioner for Transport.** "With the establishment of the two offices of general manager, East African Railways and general manager, East African Ports and Harbours, we recommend that, as the portfolio of the Commissioner (or Member) for transport embraces air and inland water transport, besides railways and harbours, the East African High Commission should appoint in future a layman to the post rather than a technician in one particular field of transport. This is the normal arrangement in the United Kingdom and elsewhere and we think it would be beneficial in East Africa."

As to this recommendation of the Committee, the High Commission's decision was as follows:

"The High Commission recognise that, whereas in the case of the general manager experience and proved capacity of a high order in the operation of railways, ports and surface transport generally are essential qualifications, the requirements in respect of the office of Commissioner for Transport do not necessarily include expert knowledge of those or other branches of transport. They would be prepared, in recommending the appointment of a Commissioner for Transport, to take advantage of special capability and special experience wheresoever derived, if it appeared that this would be in the best interests of East Africa. They do not consider, however, that the relative weights to be attached to qualifications in the field of transport and to qualifications derived from other fields can be subject to an inflexible rule, but must be determined in the light of all relevant circumstances on each occasion."

GROUP V.—Customs Procedure.

The three recommendations of the Committee referred to local problems and being accepted by the High Commission were referred to the Commissioner of Customs and Excise for his consideration and action as might be regarded as necessary.

H.F.C.

*Reprinted in "The Dock and Harbour Authority," March 1953.

New French and German Floating Docks

The Ateliers et Chantiers de la Loire, Nantes, recently completed a floating dock of 1,500 tons lifting capacity for installation at the Port of Pointe Noire, the principal port of entry into French Equatorial Africa. The port is a natural deep-water harbour, and has 77 metres of quay accessible from the sea at all times, and an assured depth of water of 10 metres. The dock, which is 92 metres in length and 16 metres in breadth, can take vessels up to 2,500 tons gross.

A floating dock to take vessels up to 165 metres in length, 21 metres in breadth, and 16,000 tons d.w., has been launched at the Lübecker Flenderwerke. This is the first floating dock built for German account since the war. All controls for sinking and raising the dock are concentrated in a single control room, and there is a comprehensive range of equipment. The pumps will enable the dock to be lifted, with maximum load, in 90 minutes. The dock is provided with two portal cranes, compressed-air plant and numerous points for connecting welding plant. Tanks are available for taking bunker oil from vessels under repair, and electricity and water supplies are also available.

The Corrosion of Iron and Steel and its Prevention

With Special Reference to Harbour and Dock Installations

By J. C. HUDSON, D.Sc., D.I.C., A.R.C.S., F.I.M.
(British Iron and Steel Research Association)

(*continued from page 53*)

3.2 Corrosion by Sea Water.

Sea water is a strong electrolyte with a low specific resistance, about 25 ohm per c.c. Consequently, when steel is immersed in it the conditions are ideal for electrochemical corrosion of the type described in section 2.3. As was stated there, the corrosion rate is controlled by the supply of oxygen. There is another secondary reaction that may be important under some conditions. The formation of alkali at the cathodes as a result of corrosion depresses the solubility of certain calcium and magnesium salts below the concentration at which they are present in sea-water. This leads to the precipitation over the cathodic areas of a white, insoluble product, which may have protective properties under some conditions. Its composition is represented by the analysis given below.

	Per Cent.
Ferric oxide	19
Calcium carbonate	57
Calcium sulphate	3
Magnesium carbonate	3
Sodium bicarbonate	5
Insoluble siliceous matter	8
Water, etc. (by difference)	5

(i) **Corrosion rates of mild steel in the sea.** There are three main sources of information about the corrosion of ferrous metals in sea water, namely the results of tests by the following organisations:

(1) **The Institution of Civil Engineers,** who exposed 2-ft. bars of several irons and steels at Auckland, Colombo, Halifax (Nova Scotia) and Plymouth for periods of up to 15 years.

(2) **L'Office Technique pour l'Utilisation de l'Acier,** who made immersion tests on a variety of plates of structural steels at Boulogne and Monaco from 1938 onwards. The experimental schedule was disturbed by the German occupation but results were obtained for up to 4 years' immersion at Monaco and 2 years' immersion at Boulogne.

(3) **The Corrosion Committee of the British Iron and Steel Research Association,** who made a series of sea-immersion tests on specimens of nearly 60 low-alloy steels, rolled from small ingots prepared in research laboratories. The specimens, which measured 3-in. by 2½-in. by ⅛-in. were immersed in sea water at Emsworth in 1946 with the collaboration of the Central Metallurgical Laboratory of the Admiralty. Two sets of specimens were tested: for 2 and 5 years, respectively.

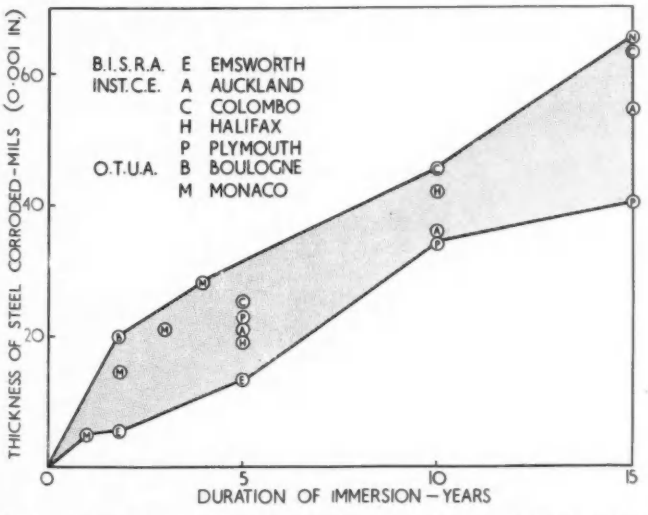


Fig. 9. Corrosion of Mild Steel in the Sea. Results obtained by the British Iron and Steel Research Association, the Institution of Civil Engineers, and the (French) Office Technique pour l'Utilisation de l'Acier are plotted in this diagram.

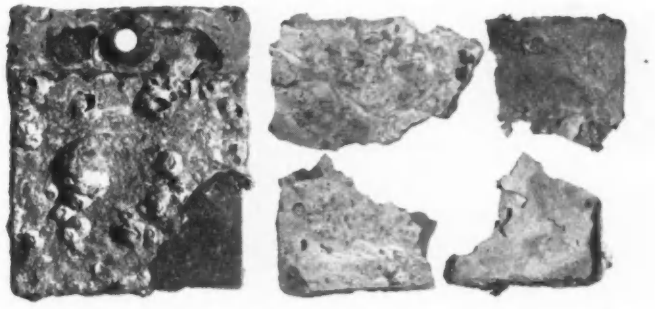


Fig. 10. Corroded Steel Specimen after 5 Years' Immersion in the Sea. The left-hand photograph shows the specimen itself, which was covered with a heavy layer of rust in which many barnacles were embedded. The right-hand photograph shows the inner surface of the scaly rust removed from similar specimens; the smoothness of this surface will be noted.

Taken as a whole, these three researches provide reliable and reasonably consistent data on the rate of corrosion of ordinary mild steel when immersed in sea-water. All the results are plotted in Fig. 9. The thickness of steel corroded has been deduced on the assumption that the loss in weight observed was distributed uniformly over the whole area of the specimen, and expressed in mils (0.001-in.).

The results show that in round numbers the rate of corrosion of mild steel in the sea is 4 mils per year. Moreover, this rate remains fairly constant over long periods of immersion. Deviations of up to 50 per cent. or so may occur from this rate according to the locality and the conditions of immersion but the paucity of the experimental data does not warrant any attempt to associate these deviations with the local conditions, such as the temperature of the water. It is probable, however, that the movement of the water plays an important part in determining the corrosion rate.

Pitting. In addition to the rate of general corrosion, it is of great practical importance to consider how far deviations from the general rate of attack will occur locally or, in other words, to what extent steel will suffer pitting in sea-water.

Little serious pitting was observed in the tests of the British Iron and Steel Research Association. For example, after 2 years' immersion at Emsworth, pits of measurable depth were found on only one specimen out of 117, although some surface roughening and preferential attack at the edges was noted on 34 other specimens. As is shown in Fig. 10, the specimens became covered with a thick layer of rust and marine growths but the rust layer had a smooth inner surface.

No quantitative results for pitting are given in the report on the results of the French experiments but those of the Institution of Civil Engineers provide some valuable data. The depth of pitting observed by them for ordinary mild steel when immersed in the sea, both in the as-rolled condition and after removing its millscale, are shown in Fig. 11. Two conclusions can be drawn from these observations:

First, as would be expected (compare Fig. 3), the presence of millscale on the steel at the time of immersion greatly increases the severity of pitting.

Corrosion of Iron and Steel—continued

Secondly, for descaled mild steel, pitting although severe is not catastrophic. Its effect at most is roughly to double the corrosion rate at the pitted areas. This means that it would take about a century to perforate a totally immersed mild steel plate one inch thick exposed to sea-water on one side only.

(ii) **Effects of differences in the composition of the iron or steel.** The next point of interest is the effect of differences in the composition of ferrous metals on their rate of corrosion in the sea. How far can this be reduced by alloying the iron or steel? Answers to this question are again provided by the three sources of information already mentioned.

An analysis of the results obtained by the Institution of Civil Engineers is given below.

CORROSION RATES OF IRONS AND STEELS IN THE SEA. (INSTITUTION OF CIVIL ENGINEERS.)

	Metal.	Corrosion Rate Mils per Year.
F	Mild Steel, C 0.2%	3.6
C	do. , do. , descaled	3.7
B	do. , do. , high S and P	3.4
E	do. , C 0.35%	3.7
A	do. , do. , descaled	4.2
D	do. , C 0.4%	3.5
D	British wrought iron, descaled	3.2
P	Swedish wrought iron, descaled	3.5
M	Ingot iron, descaled	3.6
G	Copper steel, Cu 0.6%	3.1
H	do. , Cu 2.2%	3.4
J	Chromium steel, Cr 13.5%	2.1
K	Nickel steel, Ni 3.8%	2.8
L	do. , Ni 36.6%	1.6

Fourteen different irons or steels were tested, two of them, mild steels E and F, being duplicated in the as-rolled and descaled conditions. The average corrosion rates for each material based on observations at all four sites, Auckland, Colombo, Halifax and

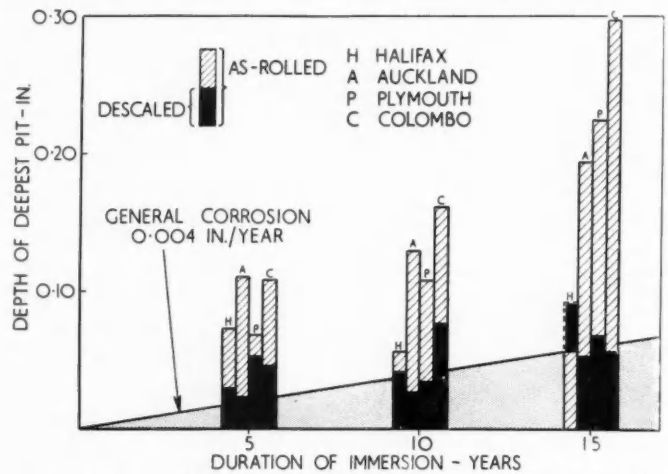


Fig. 11. Pitting of Mild Steel in the Sea. Based on data of the Institution of Civil Engineers.

Plymouth, and for each period of immersion, 5, 10 or 15 years, have been calculated from the experimental data on the assumption that the corrosion/time curves are straight lines. The experimental error in tests such as these is at least ±10 per cent. So, with the possible exception of steel A, no distinction is justified between the first 11 irons and steels on the list. The results for steels J, K and L show, however, that the corrosion rate has been significantly depressed by the addition of considerable percentages of chromium or nickel to the steel.

In these tests, begun over 30 years ago, the most modern rust-resisting steels, which contain both chromium and nickel and often other elements as well, were not represented. In all probability some of them would have shown even better resistance to general corrosion by sea-water. Rust-resisting steels do not, however, constitute an effective counter to attack by sea-water for two reasons. First of all, their superiority over ordinary steels is much less marked when immersed in sea-water than when exposed to the ordinary atmosphere. For example, in the atmospheric tests

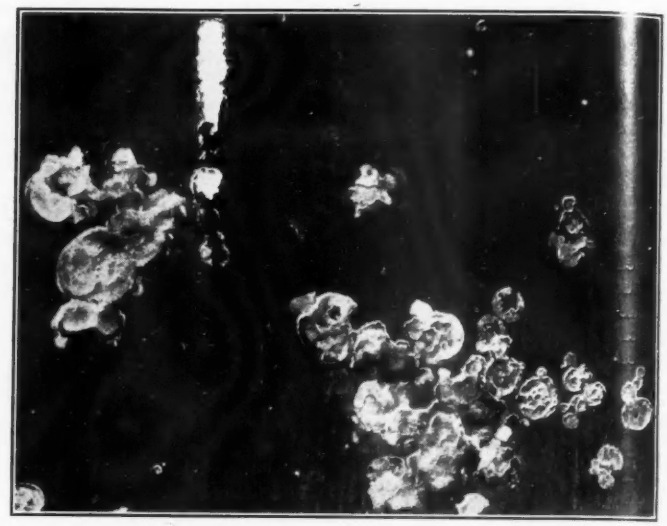


Fig. 12. Pitting of Rust-Resisting Steel in the Sea. This 0.08-in. thick sheet of "stainless iron," containing 16 per cent. of chromium, has been perforated by corrosion after 41 weeks' immersion in the sea.

of Shirley and Truman mentioned in section 3.1, 14 per cent. chromium steels similar to steel J corroded about 16 times less rapidly than ordinary mild steel, whereas in the immersion tests of the Institution of Civil Engineers the ratio in favour of steel J as compared with mild steel F is rather less than 2 to 1. Secondly, as illustrated by Fig. 12, for which the author is indebted to Mr. L. Kenworthy, rust-resisting steels show a marked tendency to pit in sea-water. This is because the protective film of oxide on their surface, mentioned in section 3.1, breaks down as soon as it is screened from the oxygen supply, as when a barnacle settles on the steel. Under such circumstances perforation can occur with astonishing rapidity and a 14 G (0.080-in.) sheet has been observed to be holed within 6 months.

No highly alloyed steels were included in the French tests and the results for other steels are less informative than those given by the Institution of Civil Engineers, because the investigators did not give the losses in weight of the specimens in their final report, but merely arranged the steels in order of merit. It is clear, however, that the overall differences in the corrosion rates of the steels tested at Boulogne and Monaco were less than about 50 per cent.

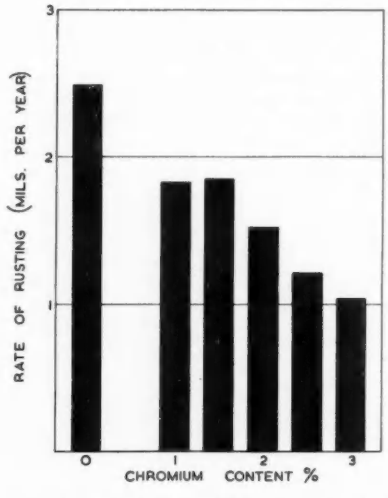


Fig. 13. Effect of the Chromium Content of Steel on its Resistance to Corrosion in the Sea. The data relate to the results of total immersion tests at Emsworth for 2 years.

The main conclusions drawn from the work of the British Iron and Steel Research Association are as follows:

(1) The carbon content of the steel up to 0.4 per cent. does not affect its resistance to corrosion by sea-water. There is slight evidence that steels with a higher carbon content, 0.6 per cent., are more corrodible.

(2) Although a wide range of alloying elements was added to the steels tested, e.g. antimony, tantalum and tungsten, the only one that can be said with certainty to have increased the corrosion resistance is chromium.

Corrosion of Iron and Steel—continued

Over two years' immersion the corrosion of mild steel in the sea was reduced to about one-third by the addition of 3 per cent. of chromium. As will be seen from Fig. 13, the effect of chromium additions increased with the percentage present.

(3) There is some indication that steels containing aluminium or beryllium may corrode less rapidly than ordinary steel. For example, over two years a steel containing 0.3 per cent. of beryllium corroded at the rate of 1.77 mils per year, as compared with 2.35 mils per year for the unalloyed steel. The influence of these two elements will, therefore, be investigated further.

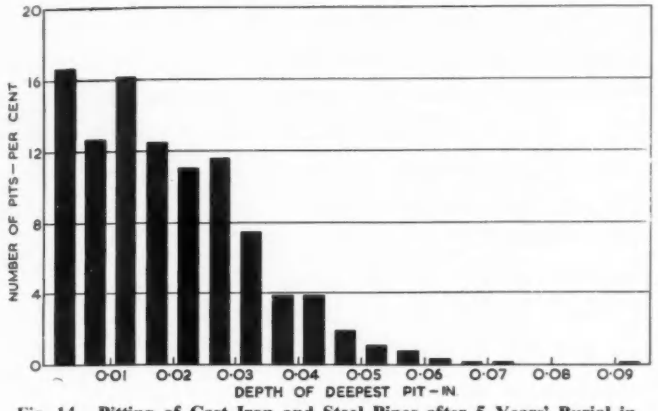


Fig. 14. Pitting of Cast Iron and Steel Pipes after 5 Years' Burial in British Soils.

(4) Otherwise, no low-alloy steel is markedly superior to ordinary mild steel when totally immersed in sea-water; this holds true in particular for the low-alloy steels containing copper and chromium, which are specially valuable for resistance to the atmosphere. In no case, however, does lightly alloying the steel lead to any significant deterioration in resistance to corrosion when immersed in sea-water.

It may be added that in these tests and in those of the Institution of Civil Engineers the general corrosion rate for cast iron was roughly the same as that for mild steel. On the other hand, cast iron is liable to suffer a particularly damaging form of local attack known as graphitisation.[6] This is due to electrolytic action between the graphite flakes present in the metal and the iron itself. The iron is corroded away locally and a plug of graphite, iron oxides and silica is left behind. This led to serious weakening of the bars exposed in the tests of the Institution of Civil Engineers.

The main result of these experiments is thus to show that there are no marked differences between the resistance of common irons and steels to corrosion by sea-water. This is a natural consequence of the fact that the corrosion rate is governed by the supply of oxygen through the water to the metal surface. The addition of appreciable percentages of chromium to the steel reduces the corrosion rate but unfortunately this is often accompanied by an increased tendency to pitting, particularly in the highly alloyed rust-resisting steels, which show a marked resistance to general corrosion by sea-water.

3.3 Corrosion by Fresh Water.

Information regarding the corrosion of irons and steels by fresh water is provided by the researches of the Institution of Civil Engineers and of the French Committee, referred to in the previous section, and by other experimental work of the British Iron and Steel Research Association.

Broadly, the conclusions to be drawn from the evidence are the same as for corrosion by sea-water. Oxygen is again the main controlling factor but there is an essential difference in that the electrical conductivity of fresh water is considerably less than that of sea-water. To give an extreme example, the specific resistance of the water of Lake Torne Träsk, within the Polar Circle at the North of Sweden, is roughly 200,000 ohms per c.c., which is of the same order of magnitude as that of distilled water. There is, therefore, more resistance to the flow of current in the corrosion cells when the corroding medium is fresh water and we should expect the rates of corrosion to be somewhat lower than for sea-water. In the main this is the case.

Another difference between fresh water and salt water is that the deposition of a protective film of calcium and magnesium hydroxy-carbonates does not necessarily occur when steel is immersed in the former. On the other hand, protective films are undoubtedly deposited from certain calcareous or siliceous waters. The deposition of a film of this type was observed, for example, by the French investigators in immersion tests made in the highly calcareous waters of the River Doubs at Dôle. They followed the gradual development of the white calcareous deposit over the red rust. After six months' immersion the film had become continuous and seemed to have attained its maximum thickness.

In the French tests there was some indication that copper-steels resisted corrosion rather better than ordinary steels but, for the reason already given, it is difficult to assess the significance of the results. It is certain, however, that the effect was not great, because the overall spread of the results, from the best steel to the worst, at the three French stations where immersion tests were made in fresh water was not much more than 50 per cent. For practical purposes it may be concluded that the effect of steel composition is roughly the same for corrosion by fresh water as for corrosion by salt water: there is little difference between the resistance to attack of the ordinary grades of steel and such alloy steels as are much more resistant to general corrosion may suffer from a tendency to be adversely affected by pitting.

Some representative figures for the rate of general rusting of ordinary mild steel in fresh water are given below.

Responsible Organisation and Place of Immersion	Test Duration Years	Rate of Rusting Mils per Year
Institution of Civil Engineers.		
Plymouth. H.M. Admiralty Fresh Water Reservoir	5	2.1
	10	1.7
	15	1.7
Office Technique pour l'Utilisation de l'Acier.		
La Cadène. The River La Truyère, which has a granite bed and is very pure water	5	2.7
Merville. The River Lys. A calcareous water polluted by industrial effluents	2	1.0
Dôle. The River Doubs. A pure but highly calcareous water	5	0.4
British Iron and Steel Research Association.		
London. Tap water; Metropolitan Water Board	1	1.5
Birmingham. Tap water; Birmingham Corporation. A softer water than London	1	1.8

It should be noted that the Plymouth results relate to steel carrying millscale. Similar specimens, which were descaled before exposure, rusted at a somewhat greater rate, particularly during the early years, but suffered much less pitting. In reporting the results, Dr. J. Newton Friend wrote: "In view of the severe localised attack on the uncleaned bars, it is clearly demonstrated that the best policy is to clean the metals free from scale before exposure to corrosion in fresh water."

3.4. Soil Corrosion.

Corrosion of iron and steel when buried in the soil may occasionally be of the hydrogen evolution type, if the soil waters are unusually acid. More often, however, it is of the oxygen absorption type. Moreover, as explained in section 2.4, serious corrosion can occur even when free oxygen is not present as such in the soil. In anaerobic soils under propitious conditions sulphate-reducing bacteria may be instrumental in providing the oxygen needed for the corrosion process.

(i) **Corrosion rates in different soils.** The rates of rusting of unprotected ferrous metals when buried in the soil have been established by British and American researches. In the United States soil corrosion studies were begun by the National Bureau of Standards in 1922. Tests in Great Britain under the auspices of the Corrosion Committee of the British Iron and Steel Research Association have been in progress since 1937. Some typical observations for the rates of rusting of ordinary irons and steels in British soils are given below.

[6] W. Westwood. "The Graphitic Corrosion of Cast Iron". British Cast Iron Research Association, Journal of Research and Development, 1935, 1, Dec., pp. 91-98.

Corrosion of Iron and Steel—continued

Locality	Type of Soil	Test Duration Years	Rate of Rusting Mils per Year
Binfield	Clay	5	1.5
Benfleet	Alluvial marsh	5	5.4
Corby	Built-up ground (cinders)	5	9.3
Gotham	Keuper marl	5	2.5
Pitsea	London clay	5	7.1
Rothamsted	Clay	5	3.4

These figures are for the general rate of corrosion deduced by assuming that the loss in weight observed was distributed uniformly over the whole surface of the specimens. For buried pipes carrying gas or water the most important factor is the maximum corrosion rate at any point, i.e. the rate of pitting. Some reserve is necessary when applying observations for the pitting of relatively small test specimens to predict the behaviour of actual buried structures, because, as the American workers have shown, there is a statistical relation between the depth of the deepest pit and the area exposed to corrosion. Clearly, the greater the area, the greater the probability of finding an exceptionally deep pit. In the American tests, the "pitting factor," i.e. the ratio of the depth of maximum pitting to the depth of general corrosion, varied from about 5:1 to 28:1, according to the metal and soil. The average value for all the tests was rather higher than 10:1. In the British tests at Binfield a factor of 13:1 was observed.

For practical purposes, therefore, the rates of maximum penetration may be assumed to be roughly 10 times greater than the figures given in the table above. The distribution of pit depth after 5 years' exposure at the sites mentioned, excluding Binfield and Corby, is shown diagrammatically in Fig. 14. The data relate to measurements of the deepest pits on each of 900 separate areas of about 24 sq. in. on 15-in. lengths of 4-in. diameter pipes buried for five years. The results for five different cast irons and steels at the four sites have been grouped together, as distinctions between sites or materials have little significance at this stage. It will be seen that about 98 per cent. of the pits were less than 1/20-in. deep.

(ii) **Effect of duration of burial.** In general the rate of corrosion of iron and steel in the soil decreases with increasing duration of burial. This is no doubt due to the fact that the rust forms at the surface of the metal and slows down the rate of diffusion of oxygen to it. An analysis of the results obtained by the U.S. National Bureau of Standards, made in 1935 by J. E. Putnam, led him to conclude that the relationship between corrosion and time in all soils was adequately represented by the equation

$$C = At^b,$$

where C is the rate of rusting and A and b are constants, which varied from soil to soil. This relationship held true both for the rates of general corrosion and of pitting.

Independent calculations by the present author have confirmed the general validity of Putnam's deductions and shown that the average depth of maximum pitting in 10 American soils conforms approximately to the relationship

$$P = 15T^{0.8},$$

where P is the maximum depth of pitting in mils, and T is the duration of burial in years.

This function is plotted in Fig. 15 and may be regarded as applying reasonably well to British soils. It should be emphasised that the curve is an average curve. The depth of pitting might be double in the most aggressive soils or several times less when the soil conditions were only mildly corrosive.

(iii) **Effect of differences in the composition of the iron and steel.** As holds good for corrosion by sea-water, it cannot be said that differences in the composition of ordinary irons and steels have much effect on their resistance to corrosion when buried in the soil. For bare pipes, differences in the corrosiveness of the soil are much more important than differences in the composition of the metal. No significant difference has been observed in the British tests, so far as they have gone, between the general corrosion of vertically-cast, metal-spun and sand-spun cast irons and various types of steel, although there is some evidence that seamless steel tubes are rather less affected by pitting. In all probability such differences as may have been reported in the service lives of pipes of different materials are to be attributed to differences in their wall thickness rather than to any differences in their intrinsic corrodibility. Spun cast iron pipes are stronger than vertically-cast cast iron pipes and are, therefore, manufactured with thinner walls than the older vertically-cast pipes, which they have largely replaced. Thus, if Fig. 15 is used to calculate the lives to perforation by pitting of Class B pipes to British Standard Specifications Nos. 1211: 1945 and 78: 1938, the following figures are obtained:

Diameter of Pipe In.	Wall Thickness In.		Life to Failure Years	
	Spun	V.-Cast.	Spun	V.-Cast.
3	0.29	0.38	42	59
6	0.33	0.43	49	69

The tests of the U.S. National Bureau of Standards provide information on the effect of alloying steel on its resistance to corrosion by soils. From an analysis of the results of tests on a series of low-alloy steels, I. A. Dension and M. Romanoff[7] deduced that these suffered less loss in weight than ordinary steel and that, although they were more severely pitted in the early stages of exposure, their rate of pitting decreased with time. Consequently, after 13 years' burial, the low-alloy steels were less pitted on the whole than ordinary steel. The magnitude of the improvement resulting from low-alloy additions is not outstanding, however, as will be seen from the following figures for the best low-alloy steel, which contained 4.7 per cent. of chromium and 0.5 per cent. of molybdenum; they are average values for about a dozen soils after 13 years' burial.

	General Corrosion Mils	Maximum Pit Depth Mils
Open-hearth steel	27.0	127
4.7% Cr, 0.5% Mo steel ...	15.3	86

High alloy steels were also tested. Broadly, the results showed that additions of chromium alone were of no value. The general corrosion rate was reduced thereby to about half that for ordinary steel but the plain chromium steels, containing 12 per cent. or more of chromium, were subject to severe pitting and specimens 1/16-in. thick were perforated in some soils within 2 years. On the other hand, austenitic 18/8 chromium-nickel steels showed remarkable resistance to corrosion, even in soils deficient in oxygen and with a high chloride content. For example, in a poorly aerated soil containing salt the loss in weight of steel with 18.7 per cent. of chromium and 9.2 per cent. of nickel after 14 years' burial was equivalent to a general corrosion rate of about 0.0002 mil per year. The maximum depth of pitting on any specimen of this steel throughout the test period was 8 mils; at the same site the rate of general corrosion of ordinary steel was about 0.8 mil per year and a specimen had pitted to a depth of 87 mils in 9 years. The excellent behaviour of the chromium-nickel steel in this type of soil is surprising in view of the severe pitting suffered by rust-resisting steels in sea-water at places where oxygen is excluded from their surface by adherent deposits (see section 3.2).

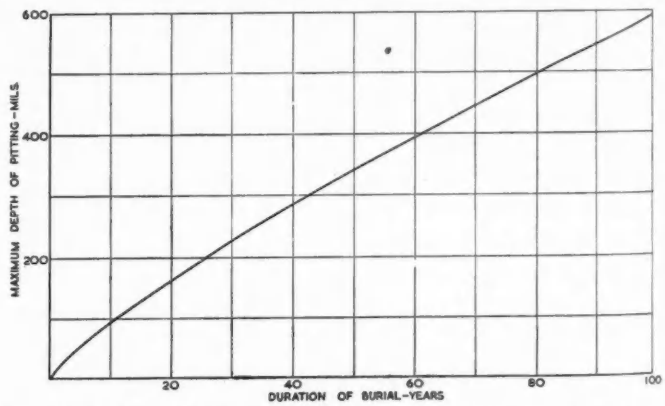


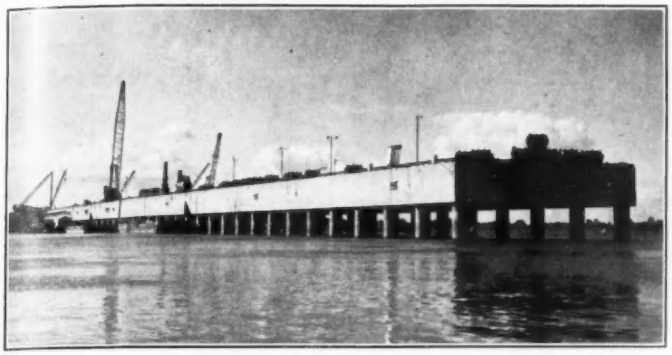
Fig. 15. Pitting of Cast Iron Pipes in American Soils. (Based on data of the U.S. National Bureau of Standards.)

It may be concluded that, although economic considerations will bar the general use of alloy steels for buried structures, their application for certain purposes where corrosion resistance is at a premium, e.g. for bolts, which are often seriously weakened by corrosion, is well worth consideration.

(to be continued)

[7] See reference 9 of the Bibliography (Section 6.3).

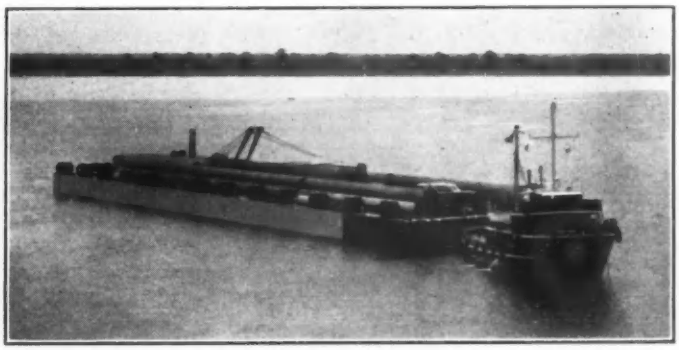
1. *Orinoco Mining Company's new ore and cargo handling dock on the Orinoco River, Venezuela. Composed of 3 units, this DeLong dock is 1,130 ft. long, 82 ft. wide, and 15-ft. deep.*



2. *A week after arrival at Orinoco River site, first dock section 376 ft. long berths ship, and unloading begins. Two additional units make this pier 1,130 ft long.*

DeLong airjack transforms sea going dock-barge into ore and cargo pier!

3. *Dock sections were economically fabricated at an Orange, Texas yard and launched for towing to pier site.*



4. *Loaded deck section arriving at site on Orinoco River, Venezuela, after being towed across 3,000 miles of ocean. Dock carried caissons crane, Airjacks, compressors, generators, and all other installation gear.*

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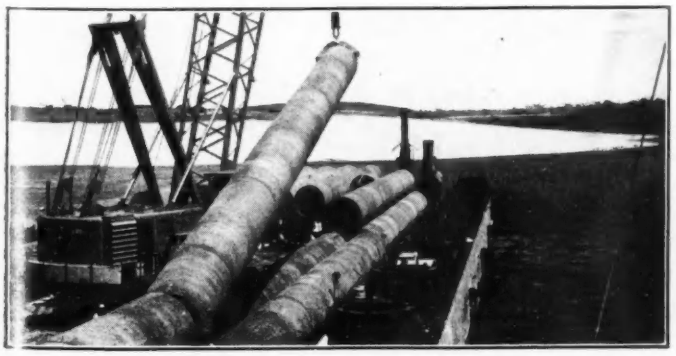
Phone: HAnover 2-1275 **Cable: DELONGDOCK**

5. *Crane placing 6 ft. diam., 100 ft. long steel caissons in wells fitted with Airjacks. Crane, Airjacks and other equipment were later transferred to second and third sections for erection purposes.*



6. *Caissons held in position by Airjacks until dock barge is jockeyed into final position. Caissons are then dropped to river bottom and Delong Airjacks lift dock to final elevation. Control is so precise, height of dock can be regulated to 1/32 of an inch.*

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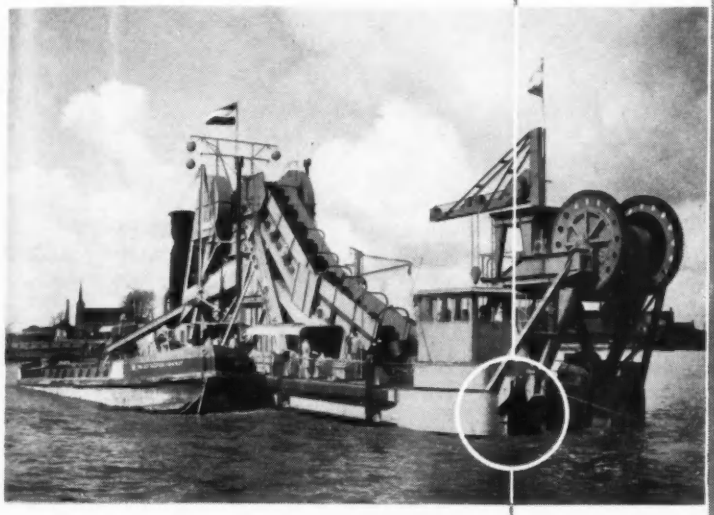

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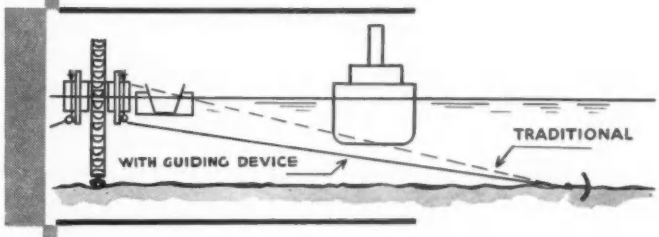

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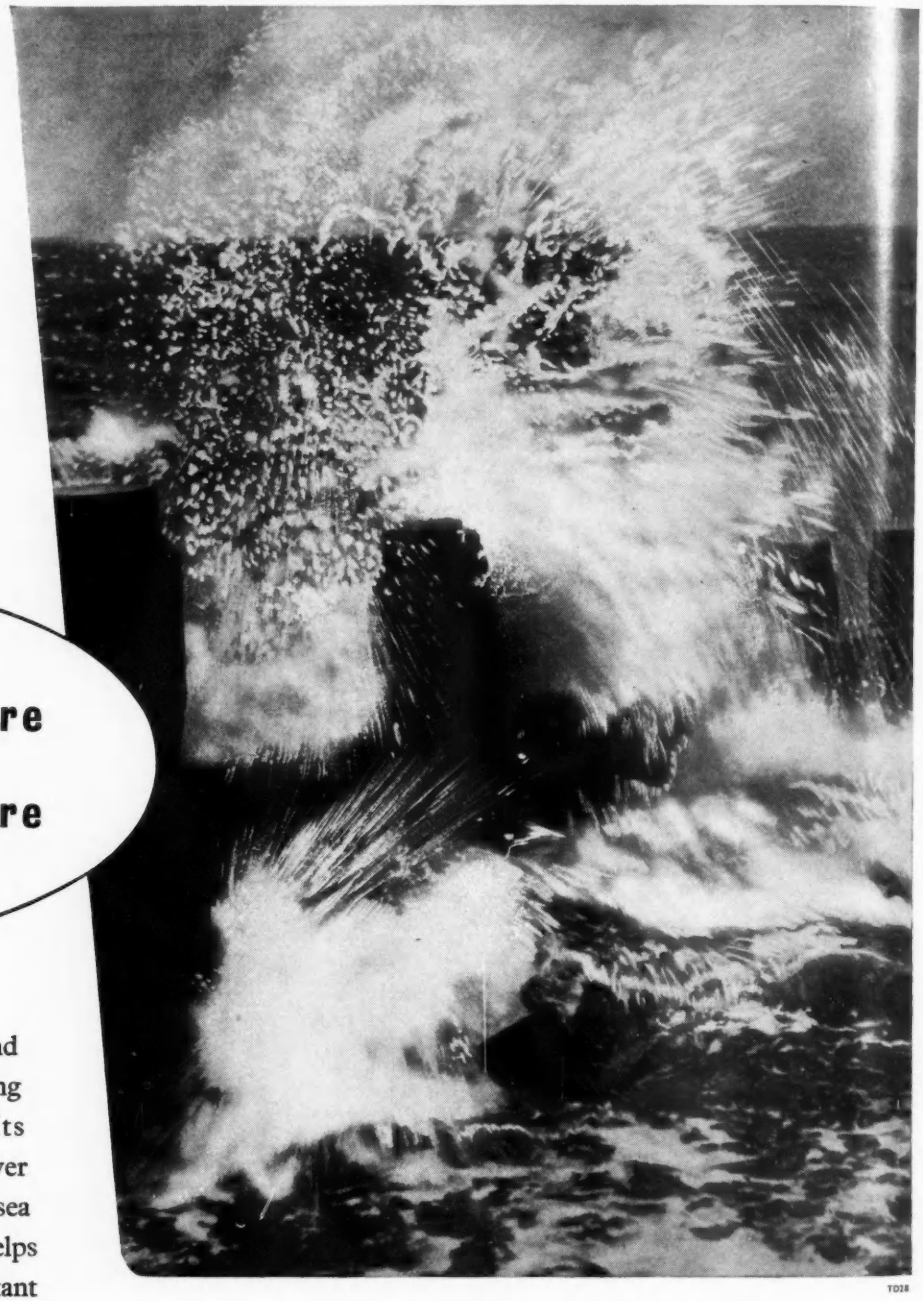

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U.K. Dock Labour Report

Review of Conditions during 1952

In a letter to the Minister of Labour, presenting the annual report of the National Dock Labour Board for 1952, Lord Crook (chairman) stated that since the end of the year there were certain observations to make to bring the information contained in the report more up to date. By the spring the labour force was brought into reasonably close balance with labour requirements, " subject to local inequalities inseparable from an industry of this nature." More recently, the period of dock workers' annual holidays had coincided with seasonal increases in trade which had resulted in shortages in certain areas. In an endeavour to overcome this problem, the Board had authorised the establishment of temporary registers in proved cases of need " as it believes that by this means the true purpose of the Dock Labour Scheme will best be achieved."

Lord Crook continued that early this year it became evident that the response to the temporary release scheme would not, in itself, sufficiently reduce the volume of under-employment and the Board introduced more attractive conditions with the result that the total number of men who took up other work (subject to their rights to reinstatement) reached a maximum of 1,196 on April 29, since when there had been a steady decline following the increase in activities.

As a result of a slight improvement in recent months, it had been found possible to reduce from August 1st the percentage payment in respect of the daily workers employed on other than coastal traffic from 22½ per cent. to 16½ per cent., with corresponding decreases for the other categories of workers. Lord Crook concluded by alluding to the difficulties of the Board in endeavouring to ascertain trade prospects on which to base a labour programme designed to facilitate the rapid and economic turn-round of vessels while, at the same time, providing a reasonable measure of security for the men in the industry.

Decline in Volume of Trade

With regard to volume of trade and employment, the report states that the decline in imports, which had begun during the third quarter of 1951, was at first partly offset by the continuing rise in exports. By the end of the first quarter of 1952, however, the volume of both imports and exports was falling, and it was not until nearly six months later that this trend was slackened and slowly reversed. For most of 1951 the Board had been building up its labour force to deal with the exceptional demands for labour. In November the register reached the peak figure of 82,521 men; at the beginning of 1952 there were still 82,330 registered workers, including over 1,200 on the temporary register.

With the recession in trade developing so rapidly the Board had no opportunity to make concurrent adjustments in the labour force, even if this had been practicable or desirable, until the extent and duration of the corresponding decline in dock work could be assessed. By the end of March, however, it was clear that the registers must be substantially reduced: as a first step all recruitment was stopped and after review temporary registers were reduced to a minimum.

It was then hoped that the ban on recruitment, normal wastage, and the increasing number of men on annual holiday would reduce surplus labour to a level which could be sustained until forward prospects became clearer. But this hope was not fulfilled and there was no slackening of the decline in employment. The number of men surplus to requirements continued to increase throughout the holiday season, and by the end of August, the potential surplus (i.e. including men on holiday) had risen to some 23 per cent. of the register.

In spite of the fact that the labour force had already been reduced by wastage to some 77,000 men the Board announced on December 4th a temporary release scheme under which dock workers in approved areas were permitted to secure other work, subject to specified liabilities as to recall and with re-enstatement rights which must be exercised not later than February, 1955. It was hardly to be expected that just before Christmas large numbers of men would take advantage of this scheme, and only 170 men had been released by the end of the year.

Turnover of Labour

The net reduction in the register was 5,608 men and this reached its greatest momentum late in the year, so that the average workers' register (79,798) was only slightly lower than the average for 1951 (80,088). Although the volume of dock work was falling off, the number of weekly workers rose during the year from just under 14,000 to some 14,400. This net addition of 400 men, producing an average of 14,274 weekly workers for the year, was a substantially slower rate of increase than in 1951 when the net additions amounted to some 1,000 weekly workers, with an average of 13,543 for the year. In view of the changed circumstances the employment of temporary workers was little more than half that of 1951.

Recruitment was virtually restricted to the completion of authorities carried over from 1951; apart from a few cases of men with special qualifications, no additions were permitted during the last nine months of 1952.

The lowering of average wages was probably the main cause of the gross wastage from the main register of 6,422 men which, excluding the special pruning of the dormant register in 1947 and 1948, is the highest figure for any year since the Board was set up. Of this total, over 3,700 men left the industry of their own accord. Since the difficulties of securing alternative employment normally increase with age, many of those who resigned were men in the lower and middle age groups whom the industry can ill afford to lose. This tendency will almost certainly be accentuated by the temporary release scheme.

In the 5½ years of the Board's operations, nearly 25,000 new recruits have been added to the main register, while 2,218 men were admitted to the main register after first being employed as temporary workers. The Board recognises that the abnormal turnover of labour, and particularly its effect on the average length of service, is a matter which is closely linked with its continued efforts to establish an efficient and balanced labour force, and regards as an urgent necessity a labour policy agreed with the National Joint Council which will enable men on the main register to be offered a reasonable measure of security over a long period.

With the exception of London lighterage apprentices, of whom 152 were trained during the year (compared with 114 in 1951), all training was drastically curtailed and only 72 registered dock workers were given specialist training, of whom 54 qualified. The total cost of training schemes accordingly dropped from £5,917 in 1951 to £2,537 in 1952. Further training schemes are under consideration, however, by the Board, which, if approved, can be introduced at the appropriate time.

General

The cost of operating the scheme during the year was £5,296,038 compared with that for 1951, £3,426,088.

The general picture was one of increasing under-employment, although a few ports—notably on the North-East coast—experienced difficulty from time to time in meeting labour requirements. Shortages were, in the main, intermittent, and of short duration; their effect was mitigated by the use of transferred and non-registered labour so that serious embarrassment was avoided. In fact, the number of ship/days lost through other causes (in itself an unusually low figure) was almost double that attributable to labour shortages.

The number of man/days lost through labour disputes was by far the lowest since the Board's inception, being no more than 12,901 man/days compared with 339,878 in 1951.

The increased rates of wages effective from February, 1952, were more than offset by declining employment, and the average gross earnings of daily workers fell successively in each quarter of the year, producing an overall average of £9 9s. 6d. per week compared with £9 16s. 6d. in 1951.

In spite of the unfavourable condition of trade, all other aspects of the labour disposition were encouraging. With no epidemics comparable with the influenza wave of the previous year, the sickness rate declined, while the effects of lower employment combined with the work of the Safety Committees produced a slight fall in injuries.

Substantial progress has been made in the Board's building programme of call stands and offices.

A Modern Monotower Crane

Some Details of its Design*

By J. PATRICK.

Introduction

CRANE design generally has kept pace with the latest engineering developments to meet the problems and demands of modern mechanical handling. The use of light alloys, the welding of steel and the latest developments in electrical control and hydraulics have all be incorporated in the most recent productions of the crane industry.

It is the purpose of this paper to describe generally and show the method of approach to a few of the problems raised in the design and manufacture of a monotower crane, which is now being used in shipbuilding.

From Fig. 1 it will be noted that this type of crane consists of a vertical mast to which is hinged on the front a luffing jib and on the rear a fixed type of ballast box. The machinery house and operator's cabin are also fitted to the mast above the tower top. The above parts all revolve about the crane centre, the lower section of the mast being located within the crane tower.

The structure of the crane is fabricated from rolled steel sections, with the exception of the jib, which is of aluminium alloy construction. The main structural members are all riveted, welding being used for a number of secondary steel members and the bogies and compensating girders of the travel gear.

Loads and Radii

The crane lifts a maximum load of 35 tons at a radius of 110-ft. from its centre.

The weight of the revolving portion (217 tons) is carried on a double-row ball-bearing footstep located at the foot of the mast, and the horizontal thrust load is taken within the mast bottom bush on the gudgeon pin. The footstep bearing is carried on the footstep girders, which form an integral part of the tower. The load from the unbalanced moment is carried by a system of compensated steel rollers bearing on a horizontal cast steel pressure ring, which is bolted to the top of the travelling tower. The combination of these rollers along with the ball-bearing footstep at the foot of the mast ensures a highly efficient sluing motion and considerably reduces the power required to slue the crane. The pressure ring and sluing rack form one unit, the racking having 288 teeth at $2\frac{3}{4}$-in. pitch, and 8-in. face.

The crane travels on 32 cast steel centre flanged rail wheels, which are carried in pairs in a compensating bogie (Fig. 2). The bogies, in turn, are carried in pairs on a secondary compensating girder. These girders are mounted on the main sill girder of the tower leg. The introduction of a system of compensating girders ensures equal wheel loading on the wheels at any one corner. The maximum wheel load, which occurs under gale conditions, is 30 tons, and under normal working conditions it is 25 tons. The rail tracks are set at 25-ft. centres, each consisting of two flat-bottom rails of 75 lb. per yard section set at $4\frac{3}{4}$-in. centres. The tower has a portal opening 20-ft. in height to allow normal traffic along the track and below the crane.

The crane will lift the following loads on a double pulley return block with a closed eye hook:

35 tons at 110-ft.
30 tons at 115-ft.
25 tons at 120-ft.
20 tons at 125-ft.

An auxiliary lift is fitted which carries loads up to 5 tons at 132-ft. maximum radius. The reason for introducing this motion is that it is more economical to use for light loads than the high-power main hoist motion.

Balance and Stability

It is the practice when balancing the revolving portion of this type of crane under working conditions to have the maximum forward moment (lifting full load at maximum rated radius) slightly greater than the maximum backward moment (no load on hook and jib at minimum radius), due allowance being made for a wind pressure of 5 lb. per sq. ft. below the tower top level and 7.5 lb. per sq. ft. above. The weight of the revolving portion is 217 tons, including 56 tons of ballast in the tank. Taking moments about the footstep bearing, the forward moment is 2,790 ft.-tons and the backward moment 2,273 ft.-tons.

Fig. 1.

Consider now the complete crane with the tower, pressure ring, travel gear and tower bottom ballast weighing 227 tons. The ballast at the tower bottom, introduced to make the crane stable under gale conditions, is 60 tons. The complete weight of the crane is, therefore, 444 tons with a maximum (35 ton) load and forward moment of 3,303 ft.-tons.

The centre of gravity at rail level is 7-ft. 6-in. forward of the centre line. The crane is stable with a load of 35 tons + 50 per cent., as the centre of gravity is 1-ft. 6-in. within the forward rail centre. The overturning moment on the crane under gale conditions is 4,631 ft.-tons, taking the wind pressure at 35 lb. per sq. ft.

*A Paper (abridged) read before the Institution of Engineers and Shipbuilders in Scotland, February 1953, and reproduced by permission.

A Modern Monotower Crane—continued

Main Hoist Motion

The full load of 35 tons is lifted on a double-pulley return block at a speed of 30-ft. per min. A change-speed gear is incorporated in the design by a sliding clutch giving a relatively fast speed of 75-ft. per min. for loads up to 10 tons, and the motor develops 110 h.p. at 700 r.p.m. The rope drum is 4-ft. 9-in. in diam. at rope centres and machine-grooved to take a non-rotating $4\frac{1}{4}$-in. circ. rope of 34/7 construction, with a breaking strain of 56.95 tons.

When lowering, the load is controlled electrically by dynamic braking and an air-operated brake is fitted to the motion. This brake is operated by a separate compressor unit, the air being used to release the brake. An electro-mechanical brake is fitted to the motor driving shaft, and the motor is connected to the driving shaft by a flexible coupling.

Auxiliary Hoist Motion

The auxiliary hoist motion has a capacity of 5 tons at a lifting speed of 120-ft. per min. It has a maximum lift at minimum radius of approximately 220-ft. above rail level and 20-ft. below. The motion is driven by a 30 h.p., half-hour rated, series-wound reversing motor controlled by a master controller in the operator's cabin. The drive from the motor to the barrel is through triple-reduction spur gears carried in an oil-tight cast iron gearbox and all shafts are mounted on ball or roller bearings.

The hoisting rope is led from the barrel over guide pulleys through the centre of the jib to the jib point. The advantage of this arrangement is that when the auxiliary hoist motion is not in use the auxiliary hoist hook will remain at the desired relative position to the jib point irrespective as to the radius of the jib.

Luffing Motion

The luffing gear consists of a worm reduction gear coupled by a flexible coupling to the 65 h.p. motor and a spur reduction gear to the barrel spur wheel, which is bolted direct to the barrel. The barrel, which is machine-grooved to suit the rope, is 3-ft. 9-in. in diam. at the rope centres. The rope carrying the jib is reeved six parts and gives a load on the barrel of 13.875 tons.

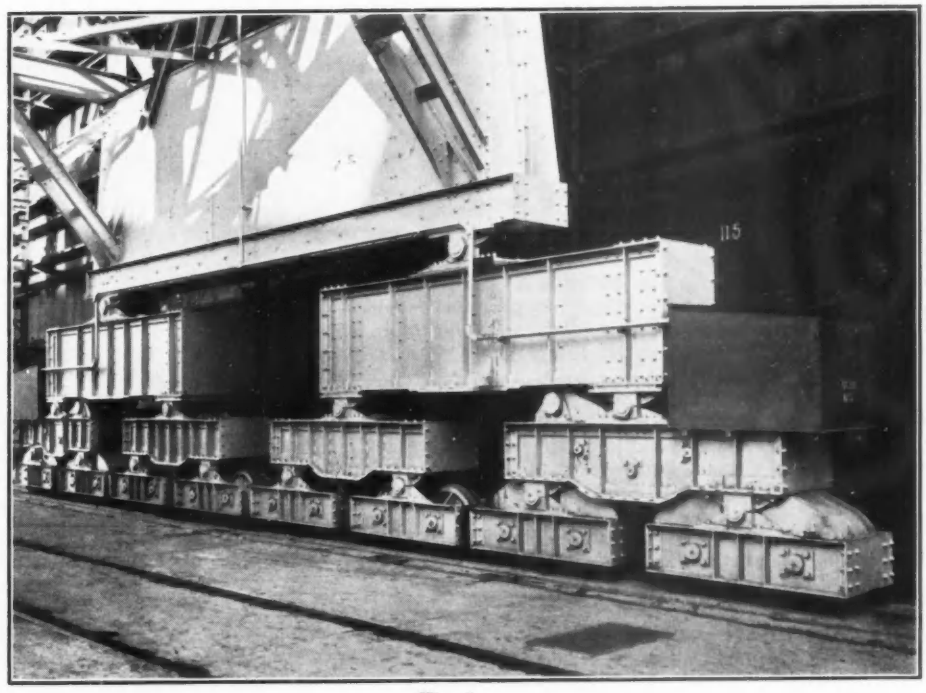


Fig. 2.

Levelling Gear

As already stated, the main lift is carried on a double-pulley return block giving four-fall reef. One end of the rope is taken to the main hoist drum and the other end to the machine-grooved levelling barrel. The levelling barrel is driven by a spur wheel which gears direct with the luffing barrel spur wheel. The ratio of this gear is such that the path of the main lift hook is approximately level when raising or lowering the jib. This arrangement has the additional feature of considerably reducing the horse-power of the luffing motor when raising the jib under load, as the pull from the standing end of the hoist rope is arranged to assist in overcoming the load from the jib rope.

Sluing Motion

This motion is driven by a 35 h.p. 700 r.p.m. motor located in the machinery house. The motor pinion is located in the centre of two spur wheels, driving them both and running in an oil-tight gearcase. The spur wheels each drive a totally enclosed worm reduction gear, which incorporates an involute spring-loaded cast iron cone friction unit to protect the sluing gear from sudden shock.

The sluing brake consists of an electro-hydraulic brake of the nipper type. Under normal working conditions this brake is hydraulically controlled, and is pedal-operated by the driver from his cabin. Electrically it is connected to the panel and comes into operation when the supply to the main circuit breaker is broken.

The sluing has to overcome the inertia of the complete revolving portion of the crane with its load. It has also to overcome the friction of the horizontal rollers on the pressure ring, the friction in the footstep bearing and any unbalanced wind pressure. The maximum load on the motor occurs when overcoming the inertia of the revolving portion of the crane and the high starting torque of a series-wound motor is utilised in arriving at the required horse-power.

Travel Motion

The travelling motion is driven by 4 synchronised motors each of 22 h.p. with one motor located on a driving bogie situated at each corner of the crane (Fig. 2).

There are 8 centre-flanged rail wheels at each corner, of which 4 are driven by means of worm and spur gears from the motor to the spur rims bolted to the webs of the rail wheels.

To absorb any undue shock, a flexible coupling is fitted on the motor extension shafts and on two of these couplings is fitted a large diameter brake wheel on which acts an electro-magnetic brake. This brake is so arranged that there is a time lag between the putting off of the controller and the coming on of the brake, in order to prevent any undue shocks on the crane structure that would arise due to a sudden braking of this motion.

Although the main current supply to the crane is 500 V. D.C., the travel motors are wound to suit 250 V. D.C. and are connected together in pairs running in series.

Electrical Equipment

To summarise, the motive power of the crane consists of the main hoist motion, operated by a 110 b.h.p. motor; the auxiliary hoist and luffing motions, each operated by a 55 b.h.p. motor; the sluing motion, operated by a 35 b.h.p. motor; and the travelling motion operated by 4 motors of 22 b.h.p. each (synchronised). These motors are all totally enclosed, half-hour rated, series-wound, reversing type, fitted with heavy ball and roller bearings. Each motor is capable of exerting a starting torque of twice full-load torque with a starting current of 1.75 times full-load current and has an overload capacity of 100 per cent. in torque for 30 sec.

In the operator's cabin is fitted a 6-motor crane protective panel, having two single-pole main line contactors with magnetic blow-out coils.

A Modern Monotower Crane—*continued*

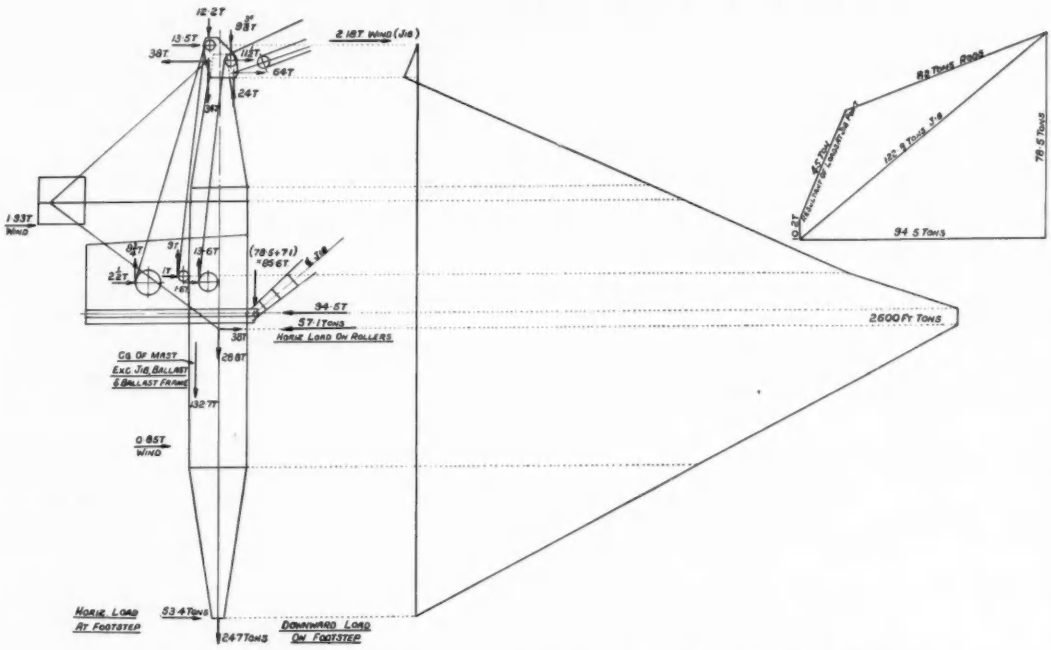


Fig. 3. Bending moment and stress diagram of mast for 35-ton load at 110-ft. radius.

Each motion is controlled by separate contactor panel, the provision for the main hoist consisting of: inductive time limit acceleration for hoisting and lowering; inductive time limit acceleration when decreasing lowering speed; full graduated dynamic braking on switching off from lowering; accurate speed control when hoisting or lowering with light or heavy load.

Control for the auxiliary hoist consists of: inductive time limit acceleration for hoisting and lowering, arranged to give plain series control hoist and potentiometer control and dynamic braking in the lowering direction.

Control for the luffing motion consists of: inductive time limit acceleration for hoisting and lowering, arranged to give plain series control hoist and potentiometer control and dynamic braking in the lowering direction.

For the sluing motion the control provides automatic reversing contactor panel to give plain series control and plugging in both directions. Plugging ensures a quick accurate stop or reversal under the control of the master switch without having to use the magnetic brake.

Control of the travel motion consists of a standard 4-motor travel panel controlling 2 sets of 2 motors, each pair connected in series. The panel is fitted with 2 sets reversing contactors for each pair of motors, and double-pole accelerating and plugging contactors to ensure acceleration and deceleration of the motors in step. The whole is designed to give smooth acceleration and deceleration and reversal without the use of a brake, under the control of the master drum controller; this is obtained by plugging.

Collector Column

A totally enclosed, slip-ring collector column is fitted above the bottom gudgeon pin at the mast bottom. It has the necessary number of rings for the main supply and feed-back to the travelling motors.

Cable Drum

The current supply to the crane is collected from a socket by means of a 4-pin plug attached to a 4-core (2 per pole) 392/.029 T.R.S. flexible trailing cable coiled on the cable drum. The desired tension is maintained by a system of suspended balance weights through spur gears to the cable drum, and the current is collected from the revolving drum by a system of slip rings and brushes. A limit switch is fitted to the drum to protect the cable against over-travel of the crane.

Mast

In the approach to the design of the mast for the monotower crane consideration of the effects of all the known loads acting on the structure had to be taken into account. These consist of dynamic, static, wind and sluing forces. The majority of these forces vary according to the magnitude of the load being lifted and the radius at which the crane is operating. The maximum forward bending occurs on the mast when lifting the full load of 35 tons at 110-ft. radius. In Fig. 3 is shown the stress diagram, force diagram and bending-moment diagram for this condition. It will be noted that the maximum bending moment occurs between the jib heel pins and the horizontal pressure ring rollers. Consideration was also given to the condition of minimum radius and no load on the hook when the bending on the mast is in the opposite direction and of lesser magnitude than the condition stated above.

The mast is treated as a strut about its full length and the maximum allowable stress determined and the actual stress at all sections kept within this figure. It is 102-ft. 6-in. in length and 11-ft. square over the corner posts. At the centre of the mast, where the maximum bending occurs, each corner section consists of two 15 × 4-in. channels with a 15 × $\frac{3}{4}$-in. web plate on the outer channel and a 15 × $\frac{1}{2}$-1in. web plate on the inner channel along with a 4 × $\frac{3}{4}$-in. flat on all 4 flanges of the channels (Fig. 4). These web plates and flange plates are curtailed or omitted on sections of the mast where the bending stresses permit of this. The mast is built in five sections for ease in assembly and erection, all joints being site riveted.

The control platform is placed in a forward position on the machinery frame platform, in a cabin separated from the main machinery house. The auxiliary hoist gear and the contactor panels and resistances are housed, each in separate compartments built into the lower part of the mast.

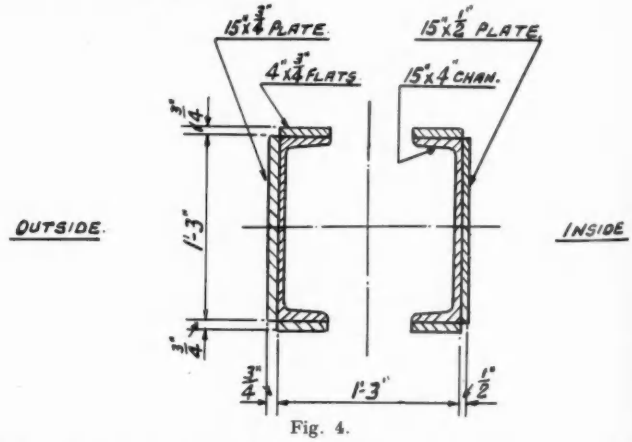


Fig. 4.

Jib

The jib of the crane is constructed throughout of aluminium alloy. The centres are 133-ft., with a cantilever extension at the point of 10-ft. centres to carry the auxiliary lift. The depth of

A Modern Monotower Crane—continued

the centre is 6-ft. over the main angles and the width 10-ft. 9-in. It is constructed of two main 4-angle sections as shown in Fig. 5. The two main angle sections are securely braced together with a system of diaphragms and horizontal bracings. The main angles are of HE15WP, having a 0.1 per cent. proof stress of 26 tons per sq. in. and an ultimate tensile stress of 30 tons per sq. in. The main bracing angles are of HE10WP having a 0.1 per cent. proof stress of 15 tons per sq. in., and an ultimate tensile stress of 18 tons per sq. in.

In designing the jib, all known stresses are considered at various sections throughout its length, the method being similar in each instance. Consider, therefore, the centre section as typical, that is, the section at the centre of the main jib length.

The actual members and dimensions at the jib centre sections are shown in Fig. 6 and the direct compressive load on the jib is 122.8 tons from the stress diagram shown in Fig. 3.

Centre Section

Outside angles (top and bottom) $6 \times 6 \times \frac{1}{2}$-in. area = 5.8 sq. in. I_{xx} = 19.97-in.^{4}

Inside angles (top and bottom) $6 \times 6 \times \frac{3}{8}$-in. area = 4.41 sq. in. I_{xx} = 15.45-in.^{4}

The inertia of the sections about the neutral axis is 42.841-in.^{4} and about the plan centre line or YY axis is 121.102-in.^{4} The appropriate modulus of sections 1,340-in.^{3} and 1,875-in.^{3}

The following stresses are considered:

Direct stress

122.8/(4 × 10.21) = 122.8/40.84 = +3.0 tons per sq. in.

Eccentric stress (due to load line)

(122.8 × 15-in.)/1,340 = 1,840/1,340 = ±1,375 tons per sq. in.

Weight stress BM = 11 × 103 × 12/8 = 1,700 in.-tons

$\therefore f_{wt}$ = 1,700/1,340 = ±1.27 tons per sq. in.

Wind stress

B.M. = (233 sq. ft. × 7.5 × 33.25 × 12)/2,240 = 311 in.-tons

$\therefore f_{wind}$ = 311/1,875 = ±0.166 tons per sq. in.

Acceleration stress

Acceleration at jib point = 1-ft. per sec. per sec.

$\therefore f_{accln}$ = (5.5 × 0.75 × 33.5 × 12)/(32.2 × 1,875) = ±0.027 tons per sq. in.

Acceleration due to load

= (35 × 1 × 51.5 × 12)/(32.2 × 1,875) = ±0.368 tons per sq. in.

Summary of stresses (top and bottom $\frac{1}{2}$-in. angles)

	Top tons per sq. in.	Bottom tons per sq. in.
Direct stress	+3.0	+3.0
Eccentric stress	−1.375	+1.375
Weight stress	+1.27	−1.27
Wind stress	±0.166	±0.166
Acceleration stress	±0.027	±0.027
Acceleration due to load stress	±0.368	±0.368
	+3.456	+3.666

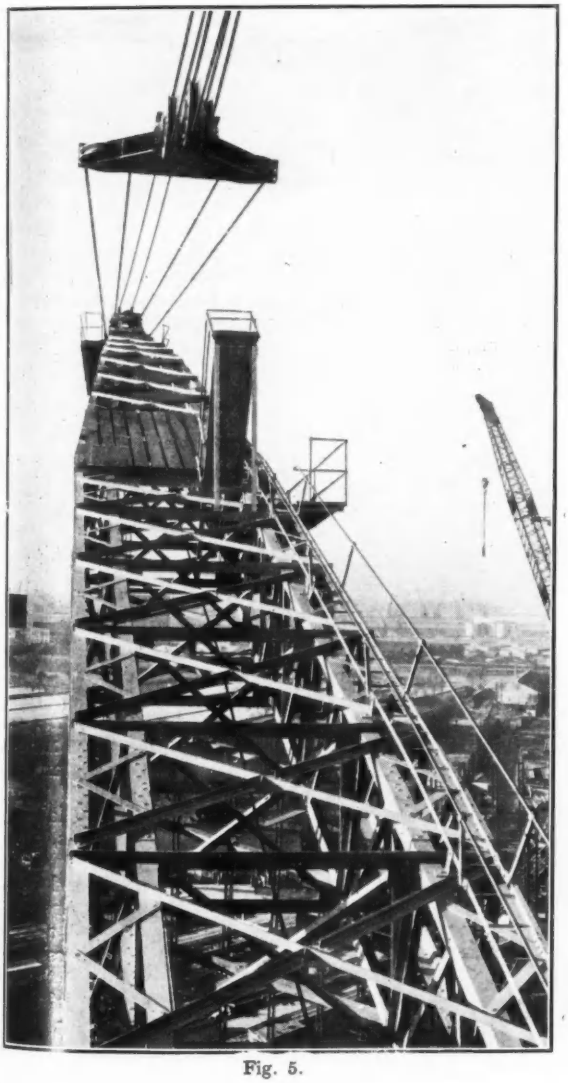


Fig. 5.

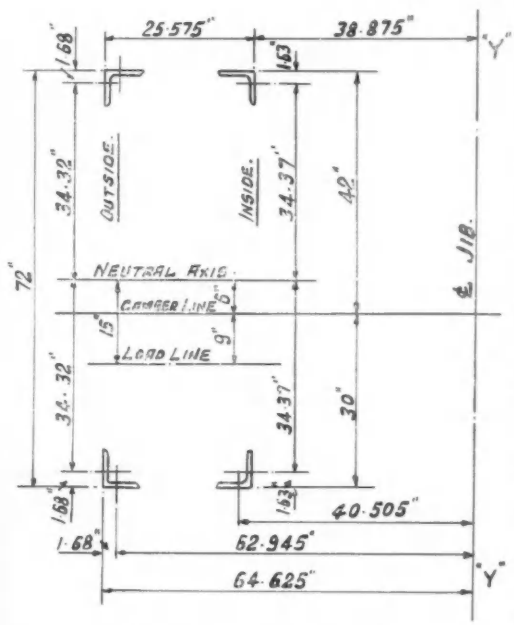


Fig. 6. Centre section of jib.

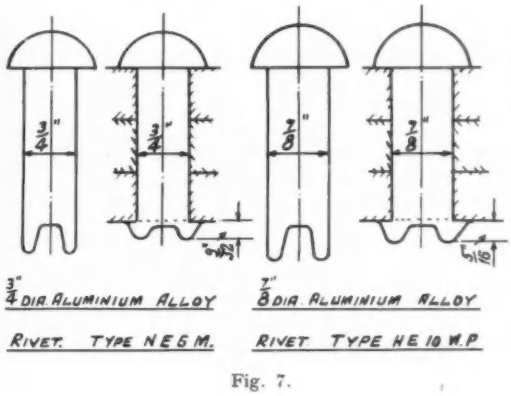


Fig. 7.

The jib is treated as a strut and the maximum allowable stress is 5 tons per sq. in. The slenderness ratio is 45.

The maximum stresses occur at a section located 33-ft. up from the jib bottom pin. They are +3.373 tons per sq. in. on the top members and +3.479 tons per sq. in. on the bottom members. Due consideration was given to the torsional and flange buckling effect on the angles.

It will be noted that recognised standard angle sections have been used throughout the construction of the jib. The introduction of bulb angle sections was considered, but the construction of the jib (for bracings in particular) presented difficult features which were against bulb angles. The bracing angles throughout are of 3 × 3 × 5/16-in. section. Rigid diaphragms are spaced at regular intervals along the jib.

The riveting of the jib presents rather an interesting feature. For the first time in crane practice ¾-in. and ⅞-in. diam. aluminium rivets were used. The ⅞-in. diam. rivets are in HE 10 WP

A Modern Monotower Crane—continued

material in order to obtain a higher shear stress and were driven cold. The ¾-in. diam. rivets are in N 6 material and were driven hot. The driven heads are of the recessed type, as shown in Fig. 7.

The sections were degreased in the shop and then a coat of a self-adherent zinc chromate primer was applied. An aluminium undercoat and top coat were then applied.

Wire Ropes

The main and auxiliary hoist ropes are of a non-rotating type, their construction being 34 strands with 7 wires per strand, ordinary lay. The jib or luffing rope is of 6 strand, 37 wires per strand, ordinary lay. The quality of all ropes is "Best Plough Acid Grade" having an individual wire breaking strain of 100-110 tons per sq. in., and the minimum factor of safety is 6.

Acknowledgment. The Author records his appreciation to the directors and technical staff of Butters Bros. & Co. Ltd. for their assistance and co-operation in preparing this paper.

The British Transport Commission

Review of Fifth Annual Report

(Specially Contributed)

When the Fourth Annual Report for 1951* of the British Transport Commission appeared in July last, interest in transport plans had already been roused by the White Paper and the Transport Bill, which had just been laid before Parliament. In that Annual Report, there was evidence of considerable progress, in four years, towards the objectives of the original Transport Act, that is to say, towards integration of the British Transport Industry as a whole. For the first time, a series of deficits was replaced by a small favourable balance, and there was evidence, throughout the whole of the Commission's activities, of some degree of success; the inevitable upheaval which had followed nationalisation had subsided, with an increase in operational efficiency.

Distress at the impending partial dissolution could be detected, here and there, throughout that report, and the Chairman's introductory remarks are worth remembering: "In this fourth year, the Commission reached financial equilibrium in their undertaking as a whole and a small favourable balance is shown, after meeting all charges properly chargeable to revenue, interest on capital in full, and a charge of nearly £3m. for amortisation of capital. If the Commission were able to proceed with their plans for the integrated development of their services under a suitably revised organisation of their administration, and if they were permitted to adjust without undue delays the level of their charges to meet the costs of the various services provided, they would look forward with some confidence to the maintenance of the equilibrium achieved." At that time it was thought apt to observe, in these columns, that the Commission was saddled with an almost impossible task in achieving integration, efficiency in operation, and an annual working profit. As to integration, with the necessity to dispose of unprofitable undertakings, the comments in these columns, last year, included the following observation: "Whether it could ever succeed (in achieving integration) with its present organisation, its statutory liabilities, its vulnerability to vociferent public pressure and with opposition from many of its employees, is open to question. Whether in achieving the elusive economies which should follow integration, the public will retain some freedom of choice, is even more doubtful, although in the Report, a powerful case is made to show that the customers' freedom will not be prejudiced."

Another year has now elapsed, and, turning from the past five years, the Commission contemplates the future with uncertainty. In the introduction to the Fifth Annual Report for 1952, fairly and factually recorded is an outline of the attitude and present position of the Commission.

"The year 1952 was the fifth year since the Commission began to take over the various constituent elements which now form their single undertaking.

The acquisition of long distance road haulage undertakings was not completed until the middle of 1951, and the national network of road services had only then assumed shape. By the date of the General Election in October of that year little more than three years had effectively been available for furthering the policy of integration for which the Transport Act of 1947 had provided. Nevertheless, plans for such integration, including long distance feeder road/rail services, joint engineering services and joint use of depots and equipment, had been brought to an advanced stage, and, after protracted negotiations with the Trade Unions, broad agreement had been reached in respect of transfers of staff. The new Government's policy obviously necessitated the suspension of most of these plans and, in particular, a halt to the progress which was being made towards a national integrated road/rail service.

In announcing their regional scheme of organisation in 1948, the Commission themselves indicated that the pattern of railway organisation which was requisite in laying the foundations of a unified railway service would be reviewed and, if necessary, revised after an initial period of two or three years' experience. The difficulties of the winter of 1950 delayed this examination, but by the end of 1951 the Commission felt that they could move towards a simpler form of organisation which, while not sacrificing the advantages and economies only to be secured by central control of certain essential matters, would lead to further decentralisation by devolution of authority to Regions, combined with the development of a road/rail service for freight traffic under a single commercial management.

Proposals designed to secure these ends were submitted to the then Minister of Transport at the end of 1951, but no consultations with the Commission took place upon them and on 8th May, 1952 a White Paper was issued, forecasting legislation which would impose upon the Commission a duty to dispose of their road haulage undertaking and would require decentralisation of the railway organisation. A Transport Bill was published on 9th July, 1952, and the Minister then invited the observations of the Commission on its various clauses, but made it clear that no fundamental changes of policy could be contemplated. Certain consultations between the Commission and the Minister ensued. The Bill was reintroduced in the autumn session and incorporated modifications of the original draft upon a number of points, particularly in respect of the charging powers of the railways, which the Commission welcomed. As to the main proposals requiring the Commission to break up and dispose of the road haulage undertaking, the Minister informed the House of Commons in the course of subsequent debate that the Commission had made it clear to the Government that they were completely opposed to these provisions. The Commission had also emphasized to the Minister the gravely disturbing effect which in their view the proposals were likely to have upon the efficiency of their services, upon their finances and upon the staff."

The Future Organisation of British Transport

The possible effects of the Government's proposals, both upon the transport system in general, and in so far as it affects dock operation and the inland waterways industry, have been fully considered in past issues of "The Dock and Harbour Authority." There seems little point in reiterating doubts already expressed. If the Commission has made slow progress in the introduction of more up-to-date methods of working, in the disposal of unwanted assets (although jettisoning "dead wood"' is not in itself progress) and in the publication of any long term plan for enlargement of selected canals and rivers to economic dimensions, for example, it is to be feared that future progress will be even less rapid. Not only will the disturbance of re-organisation and the loss of an attractive part of the Commission's assets be reasons for slow progress or even retrogression, but there are other complications. Four of the five full-time members of the Commission, including the Chairman and Deputy Chairman, terminate their appointments in August, and the majority of the members of the Executives have only had their appointments extended for one

* See "Dock & Harbour Authority," August, 1952, issue.

British Transport Commission—continued

year from last October. Added to this, the present Minister of Transport may well be rewarded for his parliamentary skill and ability by an appointment to a senior office. Until more is known about who is going to decide the policy for British Transport, it is idle to speculate upon what this policy may be.

Consolidated Results

For a full appreciation of the results for 1952, for comparison with previous years, making due allowance for recently authorised increases in statutory charges, and to assess the relative contributions made by the various Executives and parts of the Commission, the Report must be studied in detail.

The aggregate working surplus amounts to £55 million, compared with £49 million for 1951, and the nett balance after deducting central charges for administration, interest on capital and redemption items, is £4½ million, compared with £100,000 in 1951, and deficits of £14 and £21 million in 1950 and 1949.

Docks, Harbours and Wharves

The net receipts arising from Dock and Harbour operation show a marked improvement at £2.4 million (on receipts of nearly £17 million) over 1951, when the working surplus was less than £1 million (on receipts of £15 million).

The following extracts from the report will be of interest to readers of this Journal:

" The continued improvement in the financial results of the Docks is noteworthy, and the detailed figures show that for the first time since the date of vesting all groups of docks (except the Scottish group) have realised a working surplus, although certain of the docks forming part of the groups have in fact worked at a loss. This is particularly true of the fish docks where the existing charges are totally inadequate to cover operating and other costs. The St. Andrews fish docks, Hull, showed a deficit of £132,000, the Grimsby fish docks a deficit of £114,000 and Fleetwood a deficit of £82,000.

The movements of shipping using the Commission's Docks during 1952 show that increased arrivals and departures (in terms of ship tonnage) occurred at all the important groups of docks. There was an increase of 4,967,000 tons over 1951 made up as follows:

Inward Cargoes	...	Decrease	302,000	(− 1.1%)
Outward Cargoes	...	Increase	5,269,000	(+14.6%)
Net Increase	...	...	4,967,000	(+ 7.8%)

Inwards traffic of coal and coke, other food and provisions, other timber, chemicals and chemical fertilisers, and general cargo all showed reductions compared with 1951 but the tonnage of iron ore, oil and spirit, iron and steel and manufactures thereof, pitwood and mining timber all increased. Outward cargoes of coal and coke increased by approximately 3,500,000 tons and oil and spirit by 1,700,000 tons. The improved trade mainly affected the South Wales, Humber and Scottish groups of ports."

" It is estimated that the increases in wage rates account for approximately £500,000 of the increase of £884,000 in the actual expenditure.

During the course of the year further progress was made in taking out of service redundant equipment, and this has had the effect of reducing expenditure. On the other hand, approval has been given to many schemes for modernising, improving and increasing the mechanical and other engineering equipment at several of the docks. Delivery of the new equipment is subject to considerable delays but when the schemes so far approved have been completed, further substantial economies will result, together with increased efficiency and speedier discharging and loading of vessels. The costing investigations mentioned in paragraph 135 of Part I of the Fourth Annual Report have continued, and the new methods of costing employed at the docks have been of material assistance to the management. Operational research has also continued, and will be intensified as opportunity permits."

Canal Operation

Separate accounts and detailed reports are published for the two activities—" Inland Waterways: other than carrying operations " and " Inland Waterways: carrying operations." The sources of revenue for the former are tolls and dues (including those paid by the Commission upon its own carrying activities) and warehousing and wharfage. The traffic figures relate to cargo carried in all types of craft, whether owned by the Commission or by independent carriers; the majority of the traffic is still taken by independent carriers, although the Commission takes an active interest in promotion of canal traffic, whether in their vessels or otherwise. The deficit on " Canal Owning " at £123,000 is only two-thirds of that in the previous year, partly due to the increases in rates of tolls authorised.

The following paragraphs are quoted from the report:

" There was an increase of 206,000 tons (1.7 per cent.) in the originating tonnages passing over the waterways in 1952, the total tonnage having risen from 12,236,000 in 1951 to 12,442,000. The net ton-miles at 205,896,000 showed an increase of 2,430,000 or 1.2 per cent."

" Gross expenditure at £2.14m. showed a decrease of £0.19m. compared with the previous year and this decrease was due to reduced maintenance expenditure, which at £1.29m. was £0.22m. less than in 1951. The reduction in expenditure was reflected in a saving on the drawings from the Abnormal Maintenance Account. Expenditure on canals not open for commercial traffic and on those waterways which are scheduled for ultimate abandonment has been reduced to a minimum.

During the year detailed investigations have been carried out into the warehousing activities in many areas and a careful analysis of both the receipts and expenses on the warehousing and handling services has been made. These investigations, coupled with operational research into other matters, have enabled the management to take such steps as have been possible to improve the financial results of the canals, but it must be remembered that of the 1,751 miles of canals open to traffic on 31st December 1952, about 747 miles represented narrow waterways of a largely uneconomic character."

Ownership of the Scottish Canals and of canals of an uneconomic character continues to be a significant cause of the unfavourable working balance. The problem is clearly seen; the difficulty of disposal remains. At £87,000 the deficit on Scottish canals is much greater than that (£46,000) for 1951, due to the inclusion this year of losses on the canals previously owned by the L.M.S. and L.N.E. railways.

The Commission's canal carrying operations at £59,000 compared with 1951 (£88,000) show a smaller deficit, but this is largely due to the increases in freight charges ; it is likely that the defict will again increase, when the effect of wage increases made in October 1952 is felt. Some details of the year's results are quoted below:

" The total tonnage carried in the Commission's own craft showed a small increase compared with the previous year, general merchandise traffics having increased by 24,000 tons (or 5.9 per cent.) and coal and coke traffics having decreased by 15,000 tons (or 2.2 per cent.). This is the reverse of the traffic situation for the canals as a whole.

Detailed investigations were carried out during the year into the costs and receipts arising from the carriage of all commodities in the narrow boat traffics in the North Western Division and into all traffics in the South Western Division, and on the basis of these investigations action was begun wherever possible to improve the financial results. The investigations continue, and it is hoped that they will lead, in due course, to a substantial improvement in the financial results, and at least to the elimination of the deficit."

The Commission is to be congratulated upon the manner in which results and statistics are presented, and for the restraint with which they defend their position. Although confusion is inevitable from the changes in British Transport control and operation, it is to be hoped that the disadvantages and difficulties, which are so clearly exposed, will be overcome by vigorous and courageous direction and management.

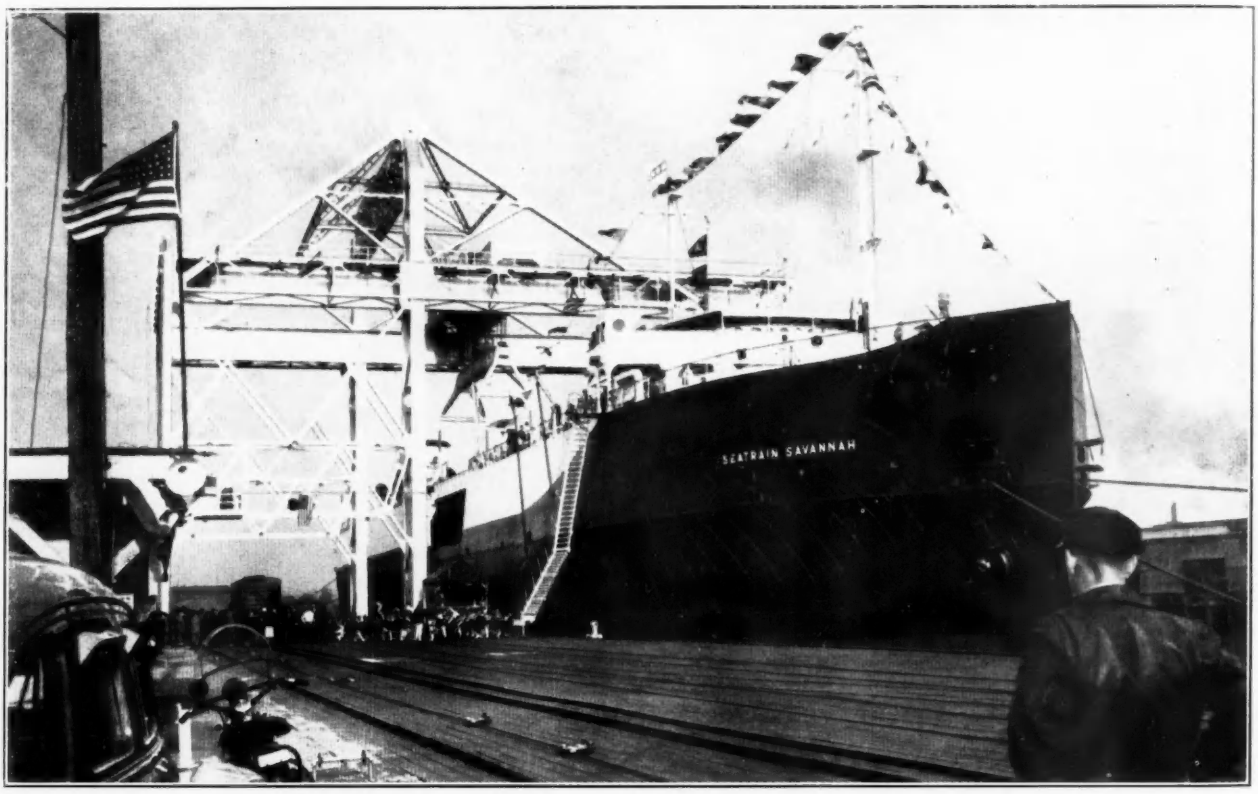
G.L.H.B.

The Port of Savannah

New Facilities and Industrial Development

(Specially Contributed)

Savannah is a deep water port on the Savannah River, which separates the States of South Carolina and Georgia. The port which is 18 miles from the Atlantic, was founded in 1733 by General James Oglethorpe, Earl of Chatham, who with a group of English immigrants founded the colony of Georgia on a high bluff overlooking the Savannah River. In view of the ever present threat of Spanish invasion from the South, the town was laid out with streets intersecting at right-angles, and with numerous squares which could be used as places of concentration in the event of enemy attack. Savannah is referred to as one of the first planned cities in America.



New Terminal and Seatrain, "Savannah," on New York-Savannah run. Capacity 100 freight cars.

During the American War of Independence, Savannah was the principal southern port on the Atlantic seaboard, and was an important point in the strategy of the opposing forces. During the American Civil War, Savannah was one of the principal Confederacy ports. It did not fall to the Union forces until the end of the war in 1864. After the reconstruction days of the South, a flourishing foreign and coastwise trade developed, centring round the export of cotton, naval stores and lumber. Many vessels called at Savannah in ballast to load, and its picturesque Factors Walk which towers above River Street was paved with stones which had been loaded as ballast in England. William Makepeace Thackeray described Savannah as "A red river with a tranquil little fleet of merchantmen taking in cargo, and tranquil warehouses barricaded with packs of cotton."

An interesting link with British shipbuilding concerns the first iron ship ever seen in American waters. The vessel was called the "John Randolph," and was assembled at Savannah in 1834, from iron plates made by John Laird of Birkenhead.

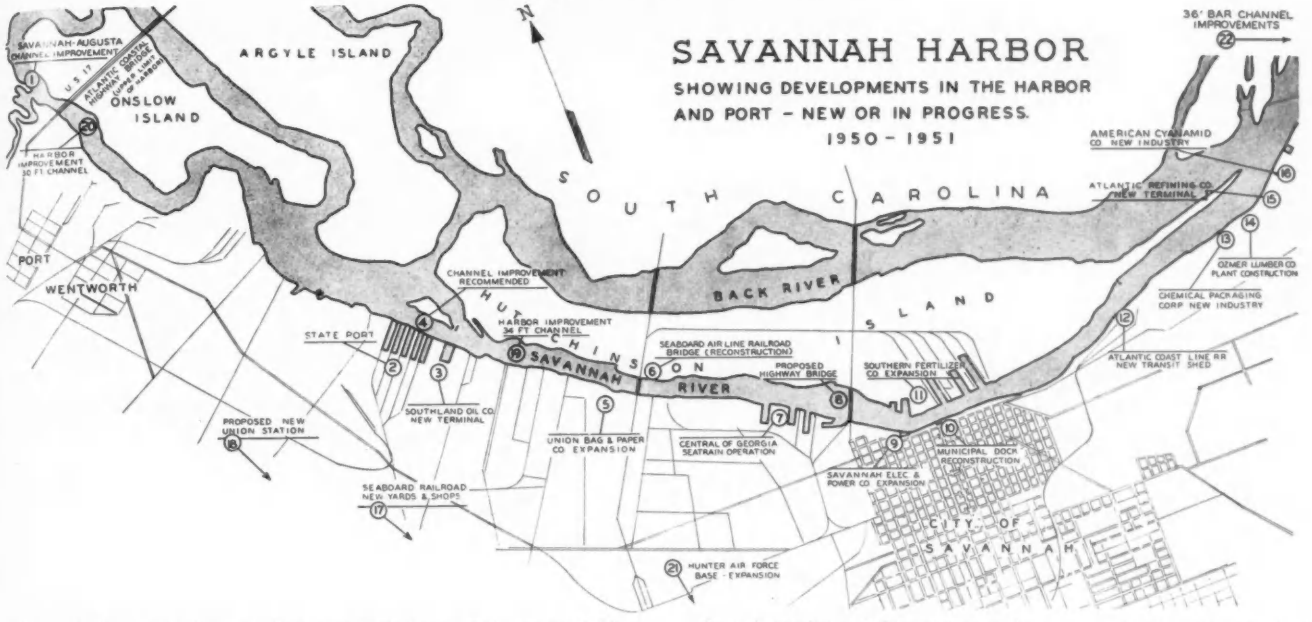
Up to the 1830's Savannah was mainly an outlet for local exports, with corresponding imports. The situation changed in 1835 when the first railway reached Savannah, and has progressively developed with improvements in transport and the opening up of the hinterland. To-day five major railways serve the port. In consequence there has grown a considerable coastwise traffic in addition to foreign trade. A peak of trading was reached in 1908 when 4,000,000 were handled. There was thereafter a decline in trade, owing partly to the First World War, and more specifically to an increase in industrial development in the Southern States as a whole. This latter led to more goods being manufactured for local consumption, with the consequence that the increased degree of self-sufficiency of the Southern States was reflected in a decline in seaborne trade. This situation is common to a number of American ports which originally came into being as an entrepôt for agricultural exports and industrial imports. It has moreover afflicted the economy of Southern American ports more than those of many other countries, because America has such a wide range of natural resources that, taking the country as a whole, it is one of the most self-sufficient countries in the world. In such cases it is not until the manufacturing potential of the hinterland is raised to a level where there is a disposable surplus that maritime trade revives.

Omitting the years of World War II, when the port was closed for nearly two years owing to enemy submarine activity and suffered other dislocations, there has been a steady recovery which is largely the outcome of greatly increased industrial development in the Southern States as a whole and in the environs of Savannah in particular.

The administrative side of Savannah's growth in recent years is of interest. In 1925 the Savannah Port Authority was established by act of the Georgia Legislature. It is claimed to resemble the Port of London Authority in character and constitution. In the same year the Savannah Traffic Bureau was formed to aid shippers and receivers of commodities using the rail and highway distributive systems of Savannah. In 1928 the Industrial Committee of Savannah Inc., was incorporated by state Charter to foster an industrial development programme calculated to maintain a sound balance in the City's economy.

The integration of the services rendered by these authorities is said to have been a natural growth, and it has culminated in the

Port of Savannah—continued


SAVANNAH HARBOR
SHOWING DEVELOPMENTS IN THE HARBOR AND PORT - NEW OR IN PROGRESS. 1950 - 1951
ARGYLE ISLAND
ONSLOW ISLAND
SOUTH CAROLINA
HUTCHINSON ISLAND
BACK RIVER
SAVANNAH RIVER
PORT WENTWORTH
STATE PORT
CHANNEL IMPROVEMENT RECOMMENDED
HARBOR IMPROVEMENT 34 FT CHANNEL
SEABOARD AIR LINE RAILROAD BRIDGE (RECONSTRUCTION)
PROPOSED HIGHWAY BRIDGE
SOUTHLAND OIL CO. NEW TERMINAL
PROPOSED NEW UNION STATION
UNION BAG & PAPER CO. EXPANSION
CENTRAL OF GEORGIA SEATRAIN OPERATION
SEABOARD RAILROAD NEW YARDS & SHOPS
SOUTHERN FERTILIZER CO. EXPANSION
MUNICIPAL DOCK RECONSTRUCTION
SAVANNAH ELEC. & POWER CO. EXPANSION
ATLANTIC COAST LINE RR NEW TRANSIT SHED
CHEMICAL PACKAGING CORP. NEW INDUSTRY
OZMER LUMBER CO. PLANT CONSTRUCTION
ATLANTIC REFINING CO. NEW TERMINAL
AMERICAN CYANAMID CO. NEW INDUSTRY
36' BAR CHANNEL IMPROVEMENTS
HUNTER AIR FORCE BASE - EXPANSION
CITY OF SAVANNAH

1. **Authorisation** made through Rivers and Harbours Act, approved May 17th, 1950, for 9 foot channel project depth to Augusta, Georgia.
2. Construction began on **State Port** facilities on January 19th, 1951. Modern terminal facilities will include 2,065 lineal feet of berthing space, 3 transit sheds 74,000 sq. ft. each, supplemented by 2,000,000 sq. ft. of existing warehouse space, and 200 acres of fine industrial sites.
3. **Southland Oil Company.** Construction began on February 20th, 1951, for petroleum distribution facilities—460,000 barrels capacity.
4. **Congressional authorisation** given U.S. Engineers to review existing reports on Savannah harbour, with particular respect to channels in vicinity of State Port. Local interests request 34-ft. channel extension to point above State Port, widening of channel, and an additional turning basin.
5. **Union Bag and Paper Corporation.** To expand present operation by the construction of a multi-million dollar semi-chemical pulping plant using gum woods.
6. **Seaboard Air Line Railroad Bridge.** Reconstruction began in July, 1950, to provide 200-ft. clearance between fenders, 135-ft. vertical clearance. Cost $1,640,940. Completed June, 1952. Eliminates navigational hazard in upper harbour.
7. **Central of Georgia Railway Company** announces "Seatrain" operations. Construction of mechanical facilities complete for loading box cars aboard vessels. Weekly service between Savannah and New York. This service replaces pre-war Ocean Steamship Company operation.
8. Proposed **Highway Bridge** shortening Coastal Highway Route 17 and connecting Hutchinson Island for future industrial development.
9. **Savannah Electric & Power Company.** Improvement and additions to be made commensurate with area growth. Cost of improvements $1,043,000.
10. **Municipal Wharf.** Westerly 350-ft. reconstructed jointly by Savannah Port Authority and City of Savannah—an important contribution to the improvement of the appearance of Savannah harbour.
11. **Southern Fertiliser & Chemical Company** to add $350,000 contact sulphuric plant to present facilities.
12. **Atlantic Coast Line Railroad Company** to construct additional transit shed at its recently rebuilt terminal facility. Shed area 33,000 sq. ft.
13. **Chemical Packaging Corporation**—manufacturing mutli-wall bags from kraft paper.
14. **Ozmer Lumber Company.** Plant under construction. Will engage in large scale lumber mill operation.
15. **Atlantic Refining Company.** Located at Southeastern Shipyard Tract. To erect $400,000 terminal facility for petroleum distribution.
16. **American Cyanamid Company.** Option taken from Savannah Port Authority on Deptford Tract—1,600 acres. To establish chemical industry of considerable magnitude. One of the most significant industrial developments in this area.
17. **Seaboard Air Line Railroad Company** will construct $3,000,000 freight classification yards and shops.
18. Proposed new **Union Station** for use of all railroads serving Savannah.
19. **34-ft. channel.**—Old Quarantine to Mexican Petroleum plant site—17.2 miles. Completed except for vicinity of Seaboard Air Line bridge now under construction.
20. **30-ft. channel**—4.15 miles. Completed. Total length of Savannah harbour —31.05 miles.
21. **Hunter Air Force Base** — to add a second bomb wing — base to be a permanent installation. $100,000,000 expansion programme.
22. **36-ft. channel**—Bar to Old Quarantine, 9.7 miles. 90% completed. All channel improvements and maintenance in harbour performed by U.S. Corps of Engineers.

establishment of the Savannah District Authority in 1951 by amendment to the Savannah Port Authority charter. This new Authority appears to have taken over all the activities of the aforementioned bodies, with the result that the entire development and Administration of the port is closely integrated with commercial and industrial needs. As will appear from a scrutiny of the plan of the Port of Savannah, there is considerable current industrial development taking place on both banks of the river. The Georgia Ports Authority has recently added to the total facilities by the construction of a State Port consisting of four new berths and three transit sheds of 74,000 sq. ft. each.

The channel ranges in depth from 36 to 30-ft.; it is intended to increase the depth to 34-ft. up to the State Port. There are 26 berths, including the four State Port Berths mentioned above. Apart from apparatus for the handling of specialised cargoes such as oil and bauxite, Savannah follows American practice in general in relying on ships' gear for cargo handling. An interesting specialisation is the new Seatrain Terminal (shown in the illustration) which handles freight cars to and from New York, the northern terminal being in the Hudson River at Edgewater, New Jersey. A weekly service is operated between the two ports, the ship "Seatrain Savannah" having a capacity of 100 freight cars.

Latest available figures suggest that in 1952 the total seaborne trade of Savannah will for the third time reach 4,000,000 tons, the previous occasions being in 1908 and 1940. In view of the considerable industrial development of recent years, coupled with heavy investment in harbour improvement this figure is likely to be surpassed in years to come.

Clyde Trust Schemes

At a meeting of the Clyde Navigation Trust held this month, approval was given to a series of schemes to provide additional berthage and facilities to meet the needs of ocean ships at Glasgow Harbour. These schemes would comprise the biggest reconstruction programme formulated by the Trust since the end of the war, and the whole project is estimated to cost nearly £2,000,000. This expenditure will involve four or five schemes within the harbour, and consideration will be given, at a later date, to the provision of a new basin west of the King George V Dock, the cost of which will be in the region of between £8,000,000 and £9,000,000.

Among the improvements to be undertaken will be the building of additional berthage at the Queens Dock, which at present cannot be used satisfactorily, and at Springfield Quay, more cranes are to be erected.

At the meeting, the question was raised concerning Glasgow Corporation's plan to construct the Whiteinch-Linthouse tunnel under the Clyde. The speaker said that the trustees' decision to provide more adequate facilities at the harbour for handling traffic and movement of cargoes was welcomed, but it appeared to him that the tunnel scheme was also associated with that question; it tied up strongly with Glasgow's need of cross-river communications.

With regard to the time to be taken on these projects, some months will elapse before tenders are received, but it is believed that the benefits will begin to accrue in from two or three years, by which time the Trust should be getting additional revenue from their expenditure.

The Increased Scope of Modern Welding

New Methods of Approach

By C. W. BRETT, M.Inst.W.
Managing Director of Barimar Ltd., Scientific Welding Engineers.

There are important technical differences between the application of scientific welding to new construction and the indispensable use of similar methods applied to repair work. In the case of the former there are never the same wide variations in the correct method of approach nor, for the most part, the frequent difficulties of limited accessibility and so on. In this connection it is not too much to claim that when the conditions are complicated then welding is the only logical solution.

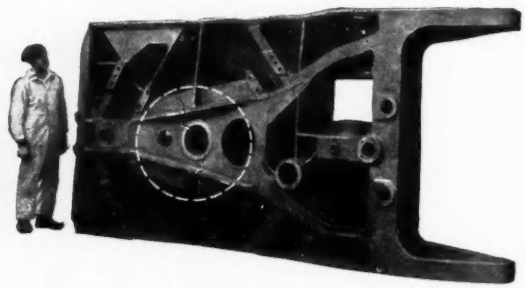


Fig. 1.—6-ton bedplate of large excavator. Serious cracks developed in the centre of the casting through the king post housing.

With new construction, provided that the operator is properly trained, then the text book can be followed, but for repair and reconditioning work it has been necessary to perfect new techniques. This aspect is illustrated by the important progress that has been made in regard to heat control. Many components in need of repair are so heavy or bulky that the only economical procedure is to handle them on the site. Furthermore, effective pre-heating may be impossible. Entirely new methods of approach have rendered preliminaries of this kind unnecessary. Even when cast or malleable iron is involved, after normal preparation, the work can be commenced immediately without fear of distortion and consequent stresses in the metal. This is an enormous advantage for it makes possible not only the most efficient means of repair but also the least costly, although it does imply the need for highly trained operators and explains why the great bulk of this work is handled by a comparatively few specialist firms who are willing to guarantee successful results.

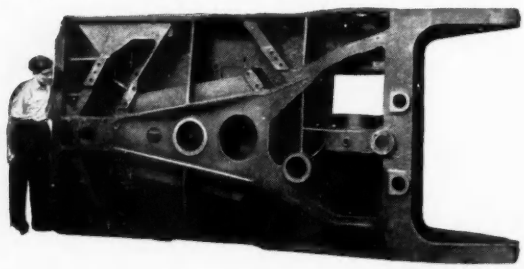


Fig. 2.—A perfect repair was made by scientific welding, which showed a big saving on the cost of a replacement.

Another advantage afforded by welding is the substantial gain in strength that can be achieved. An increase of over 100 per cent. is by no means out of the question and this is of special importance when stresses are encountered beyond those originally envisaged. Take, for example, the main casting of the transversing gear belonging to a bucket dredger operating on the west coast of this country. The weight of this component is nearly 4 tons and it is 12-ft. in length. The two main bearing housings were torn away entirely and for the particularly heavy work on which this dredger is engaged it was necessary to increase the margin of strength. It is not generally appreciated that this is not the most difficult objective facing the welding specialist, for the preservation of true alignment to an accuracy of plus or minus 0.001-in. is more demanding upon skill and experience. Nevertheless the job was accomplished with complete success.

Similarly the 6-ton bedplate of an excavator used on [illegible]rt work in Ireland was severely cracked on both sides of the [illegible]ng post housing through metal of considerable thickness but s[illegible]ll below the practical limit of 10-ins. to 12-in. thick. The casting was sent to London for repair and as the work occupied only a [illegible]ew days the saving in time alone effected a substantial economy not forgetting to take into account the cost of handling and transport.

Equally good work has been carried out upon a numbe[illegible] of dock pumps and engines. A recent repair of this nature con[illegible]erns the combined crankcase and base casting of a 200 h.p. Dies[illegible]l engine coupled to a pump. This casting, which weighed 4 tons, 10 cwts. and was 10-ft. in length had a large piece broken out of the mounting flange. Here again the combination of strength and accurate

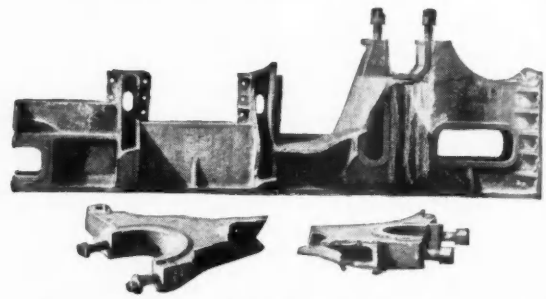


Fig. 3.—The traversing gear of a dredger. The casting was 12-ft. long and weighed between three and four tons. A replacement would have had to be re-cast and machined specially, involving heavy cost and serious delay.

alignment were paramount but the result proved the wisdom of shipping the casting to this country, for the expenditure was far less than the cost of replacement.

Interesting as is work of this kind, too little emphasis has been put upon the opportunities that scientific welding affords to counter excessive wear and corrosion. In these days there is such a wide selection of weld metal that substantial advantages are gained by careful choice of the materials employed. Instances are constantly arising in which the life of a part subjected to heavy abrasive action and for which adequate protection is impossible, has been prolonged up to two and a half times beyond that of a new component costing far more than the application of a special steel deposited by welding. Stainless steel, monel metal and other materials are frequently used to counter the effects of rapid corro-

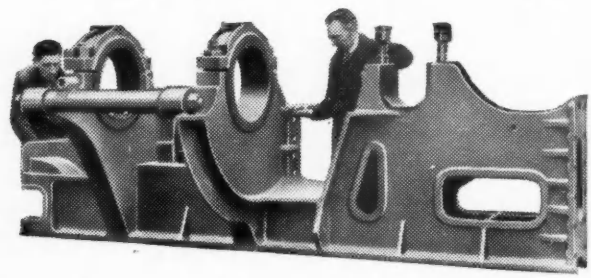


Fig. 4.—A satisfactory repair was made by scientific welding, and the dredger was back in service after a very short period of idleness.

sion, therefore when considering repair work it is a limited outlook to confine the problem merely to the reunion of cracked and fractured metal, for the possibilities are far wider than this.

Whilst these practical facts are most important, they tend to overshadow the efficient general organisation that is behind scientific welding When an emergency breakdown arises that must be handled on the site it is not always appreciated that operators are constantly in readiness, day and night to go with portable self-contained equipment to wherever their services are needed.

It is the adaptability and wide scope of scientific welding that makes it so important, for it can do so much more than any other means of repair and at lower cost.

Scheme for New York Dockers

Plan to End Present Hiring System

According to a report just received, the International Longshoremen's Association of the United States has worked out a plan to abolish the "shape-up" system of hiring dock workers. The "shape-up," whereby a hiring boss selects whichever men he prefers from those lined up for work at a pier, has for some time been the subject of much criticism, and the present proposals are designed to put an end to alleged abuses on the waterfront. The details of the proposed plan are as follows:—

1. Twelve geographical hiring centres to be set up in the Port of New York to be operated jointly by the union and the employers.
2. All regular gangs of dock workers and regular terminal labour to be assigned to the piers where they had previously worked. All extra gangs and all individual workers to go to their nearest hiring centres where they would be employed on a rotating basis in the order of their registration.
3. If no work is available for a regular gang at its regular pier, this gang to go to the district centre and be registered as an extra gang. Individual workers would do the same.
4. The hiring centres to be financed by the employers but administered jointly by the unions and employers.
5. An adjustment board, consisting of four union and four employer representatives, to be set up to handle disputes over contract terms and grievances of workers; in the event of the failure of the board to give a majority decision, the controversy to be referred to an impartial arbitrator.
6. Penalties to be imposed for employer violations of the hiring centre arrangement; union officials violating the plan to be subject to the loss of their positions or expulsion from the union. Alleged violations to be referred to the adjustment board.

The plan, which has been worked out by a committee of 18 leaders of the union in the New York area, will be submitted to the Legislature and the New York Shipping Association. The union's contract with the latter expires on September 30th, next.

Bombay Dock Workers

Agreement Regarding Decasualisation Scheme

According to a report issued by the International Transport Workers' Federation, a dispute between the Bombay Dock Workers' Union and the Bombay Port Trust concerning the employment of dock labour has been settled by an award of the Industrial Tribunal.

The dispute, which has lasted for over two years, was mainly concerned with the interpretation of the Bombay Port Trust decasualisation scheme, which was put into effect in September, 1948. This latter, which applies only to dockers employed by the Port Trust and not to port labour recruited by stevedore and other contractors, provides for two main categories of workers. The first of these, Category A, is made up of permanently-employed dockers. Category B, on the other hand, is a semi-permanent reserve intended to replace Category A workers during leave or sickness. In addition, there exists a third group, known as the third shift, made up of purely casual workers not covered by the decasualisation scheme.

When the scheme was put into effect, the Port Trust reduced the strength of Category A from 2,300 to 2,014 and that of Category B from 500 to 200, increasing the number of casual workers to 2,500. The Port Trust's action was strenuously opposed by the Dock Workers' Union, which contended that this was not decasualisation, but "recasualisation" of workers who would otherwise have benefited from the scheme.

The union therefore put forward the following demands, which were finally submitted to the Industrial Tribunal:—

(1) the number of workers in Category A to be raised to 2,800;
(2) the number of workers in Category B not to exceed 500;
(3) recruitment to Category A to be solely from Category B;
(4) the attendance allowance paid to Category B workers to be increased;
(5) workers to be given twelve days' leave per year; Sundays to be treated as weekly holidays with full pay.
(6) rules on promotion to gang morpia (in charge of thirteen men) to be laid down;
(7) recognition of the necessity of filling vacancies for morpias and special morpias;
(8) Category A and B workers to have preference over casual labour in work on the third shift.

In its award, the Tribunal fully conceded claims (1), (2), (3), (6) and (8), partially conceded (5) and (7) and rejected (4) outright.

Commenting on the award, the General Secretary of the Union said that it was satisfactory and that he hoped it would be implemented by the Port Trust without delay.

Publications Received

"The Journal of Transport History," Vol. 1, No. 1, edited by Professor Jack Simmons and R. M. Robbins. Published twice yearly, in May and November, by the University College of Leicester. The subscription rate is 18s. per annum, single copies 10s. each. Subscriptions should be sent to the Secretary, Publications Board, University College, Leicester.

This publication, the first number of which was published in May, aims at giving a comprehensive treatment of transport history and intends to stimulate original research into the subject; to view transport as a whole by including in its scope all forms of transport, from trackways to aircraft, in all ages; and to provide common ground for professional historians and transport men.

The reason for the establishment of such a journal is that the history of transport is of high importance in its bearing on many historical questions, and although some of its aspects have been studied very thoroughly others have been neglected.

The British Transport Commission, which controls a substantial part of all the transport undertakings in this country, is opening its historical archives to students, and an increasing amount of work is being done upon them, but there is no suitable medium for publication of these studies as they are carried forward. Furthermore, there is need for a periodical that shall view the history of transport as a whole and not be limited to the consideration of any one form of transport and which shall offer common ground to historians both in the academic world and in the world of transport.

The journal's scope is transport of all kinds and in all ages, covering the history of ports and shipping, railways and air transport, and it is intended to also include articles on inland waterways and on road transport.

Although transport in Great Britain will be the principal interest, developments in other parts of the world will not be excluded.

Ports of the World. Edited by Sir Archibald Hurd, London: The Shipping World, Ltd., Effingham House, Arundel Street, Strand, W.C.2. Price, post free, 80s. net.

This is the seventh edition of this comprehensive reference work. The editor states that an unusually large volume of corrections and new material which has been incorporated in this new issue represents a considerable step forward from previous editions. All sections have again been revised and expanded, notably those dealing with North America, Europe and the United Kingdom.

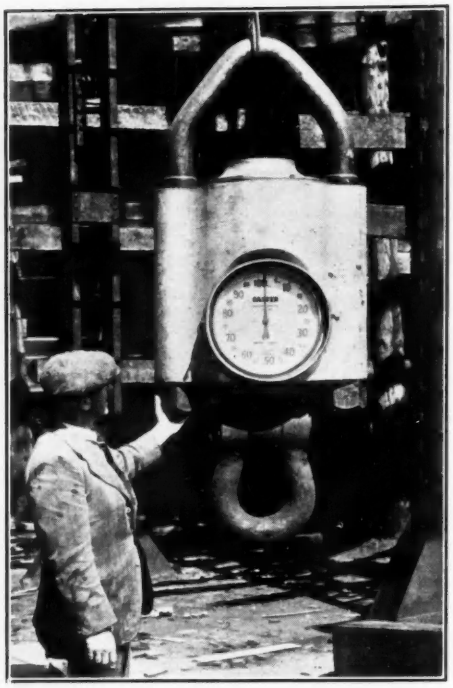
Many new ports increasingly used by shipping are now included for the first time, and a number of smaller ports have been added to the European sections, bringing the total of ports now listed to over 1,800. The index contains over 2,000 references. The simple guide to liner services operated from the U.K. to overseas ports has now been enlarged, and further progress has also been made with the policy of summarising national changes at the beginning of each section.

Ship-Shape, a new official publication issued quarterly by the Port of Bristol Authority, aims at promoting the activities of the port. The first issue is profusely illustrated and contains articles on: Trades of the Port—The Importation of Tobacco; The Meat Trade and the Port of Bristol; Shipping Lines Associated with the Port; and Elizabeth I and Bristowe Port.

Manufacturers' Announcements

Weighing and Lifting in One Operation

In many of the biggest and busiest ports throughout the world, the Salter Crane Weigher is in operation. The apparatus is attached to the crane hook and enables the weighing and lifting of freight to be carried out at the same time, thus eliminating a separate weighing operation, and so resulting in a speedier handling of cargo and expediting shipping turn-round. It also provides the quickest and most reliable method of testing the load capacity of the crane itself. The machine is manufactured by George Salter & Co., Ltd., of West Bromwich, Staffs., in a range of standard capacities from 10 cwt. to 100 tons. Larger models are built to order, in fact, a 200-ton weigher is at present in the process of construction for the English Steel Corporation. These machines can be supplied with either a hook or a shackle for attaching the load, and the weight lifted is shown in an instantaneous reading. The dial is protected by armour plate glass, and a warning hooter, set to any predetermined load, can be fitted. A number of sizes in the standard range are suitable for trade purposes and can be stamped by the weights and measures authorities. The illustration shows a weigher, capacity 100 tons, in use at Greenock Docks.



The Merton Overloader

Distributed by Mackay Industrial Equipment Ltd., of Feltham, Middlesex, the Merton Overloader, which hitherto has been chiefly manufactured for export, is now available on the home market. It incorporates several new principles in design. Foremost advantage over the more conventional types of loader is that it operates in a straight line working backwards and forwards between the lorry and the dump. The operator only has to change from forward to reverse and there is no wear and tear on the front axle or steering gear or wasted time while the machine is being manœuvred into position. The loader can operate in narrow cuts and confined space needing only its own width. On difficult terrain in wet conditions, the straight line operation of the machine avoids making a quagmire of the ground and if necessary a simple straight temporary road can be laid by the use of sleepers or hardcore. The use of this machine for discharging bulk cargoes at ports was described in the March, 1953, issue of this Journal.

Radio-Telephone System at Singapore Harbour

Following the successful operation of radio-telephone equipment which has been in service for some time, the Singapore Harbour Board has placed an order with The Marconi International Marine Communication Co., Ltd., for the installation of similar equipment on board four more of the Board's tugs.

By providing instant speech communication facilities between the shore office and the two tugs engaged in berthing duties about the harbour, the system has effected a considerable saving of time and fuel, the Wharf Superintendent being able to control the tugs' movements without their having to return to their own berth or steam to an outlying telephone to receive instructions. The experience gained has now decided the Board to extend the system.

PUBLIC APPOINTMENTS.

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Further particulars and application forms can be obtained from:—

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quoting reference A/B 3/74/87 and the name of this paper. Completed application forms must be lodged at the above office not later than Friday, 7 August, 1953.

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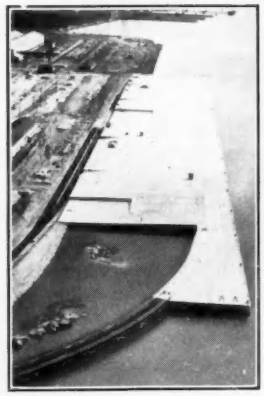

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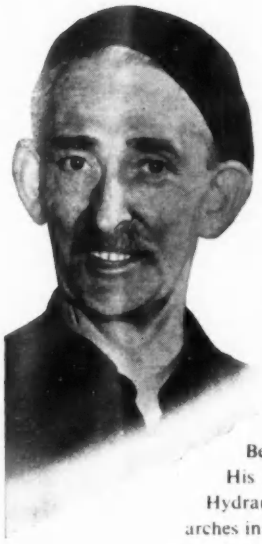

This man reconditioned 8,000 steel rings in 138 days

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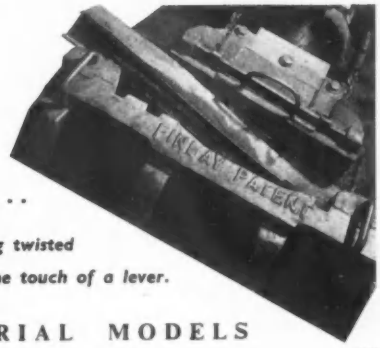

THIS IS HIS MACHINE IN ACTION . . .

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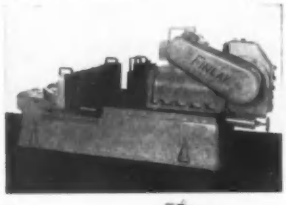

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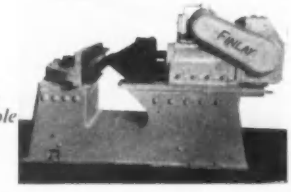

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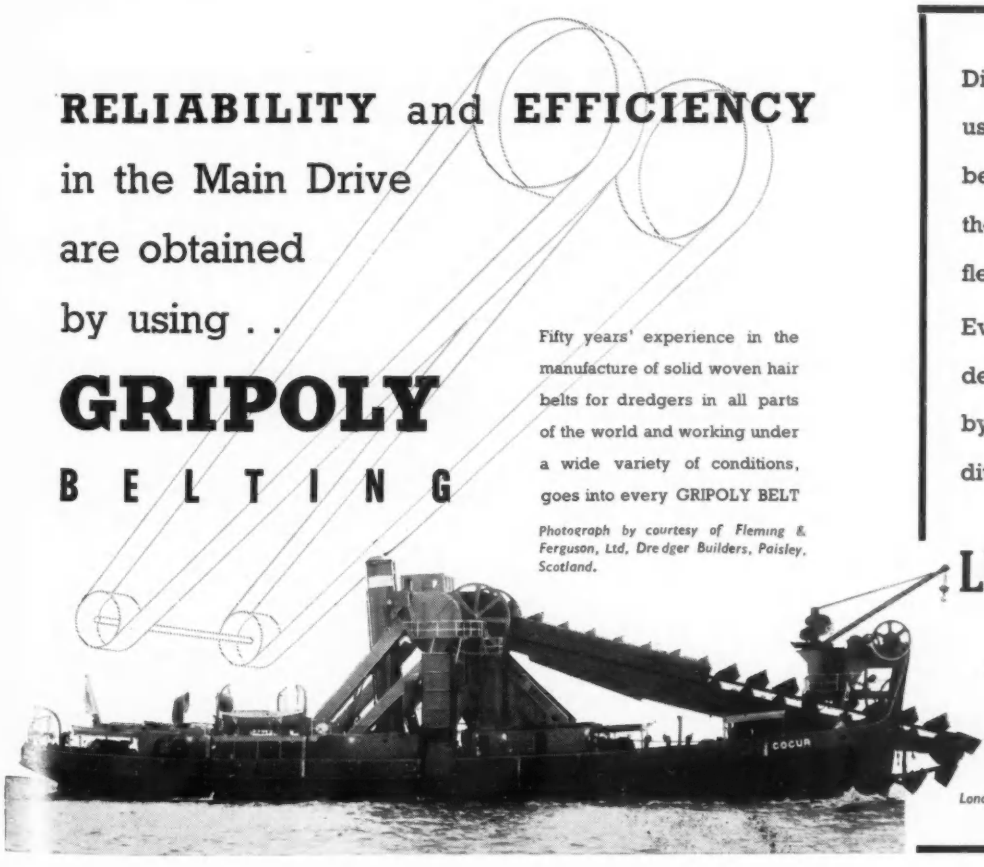

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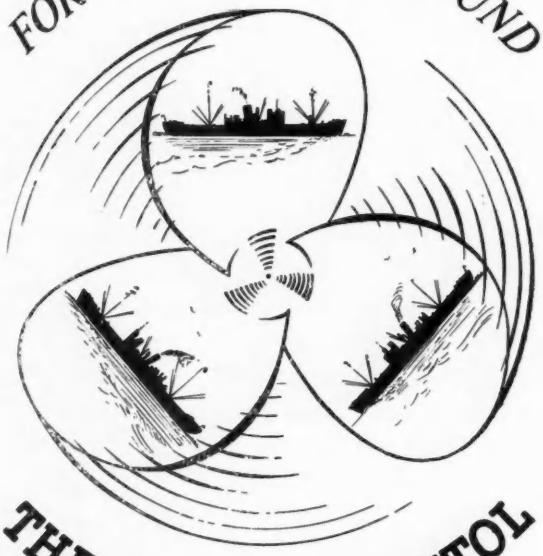

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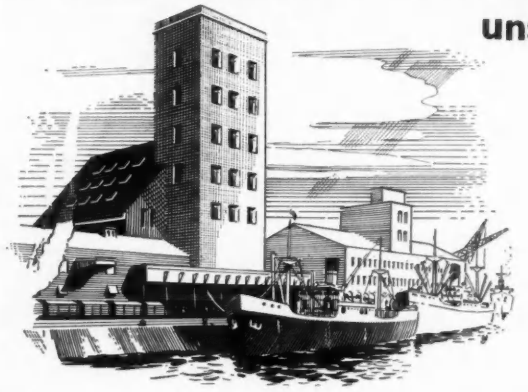

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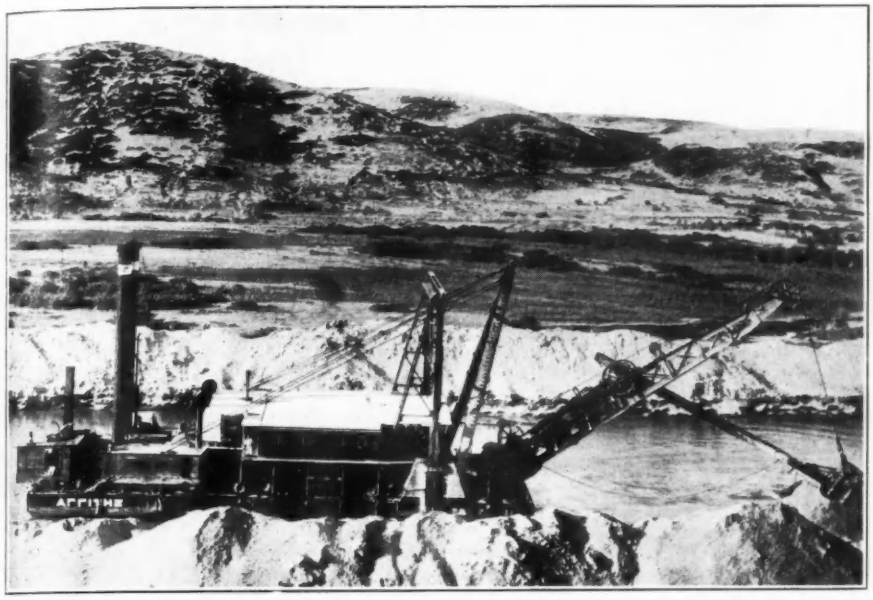

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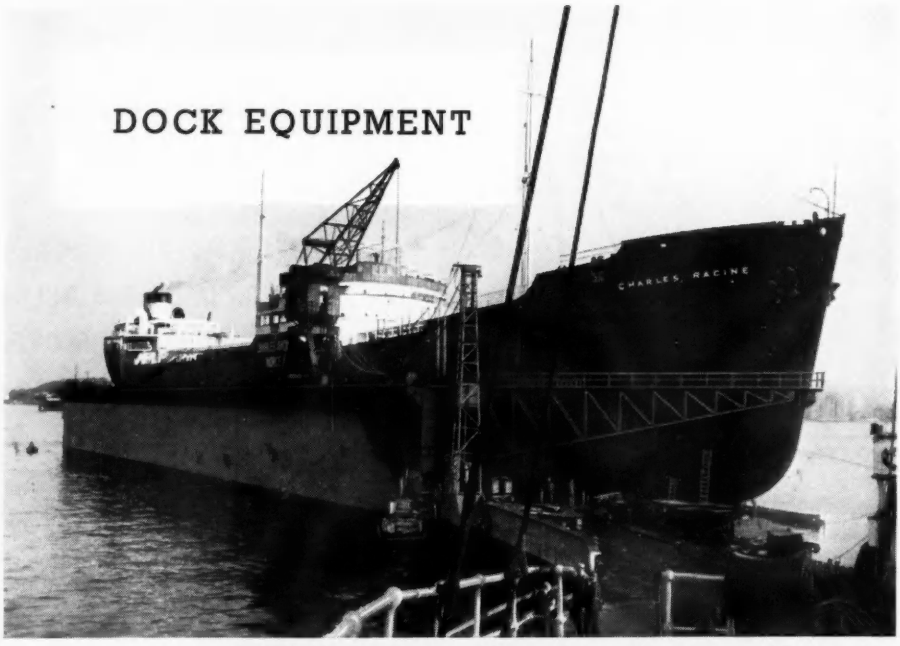

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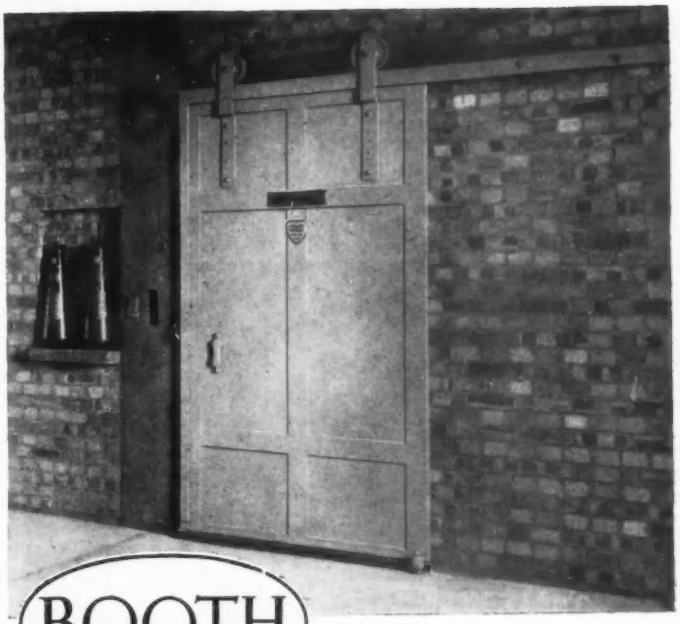

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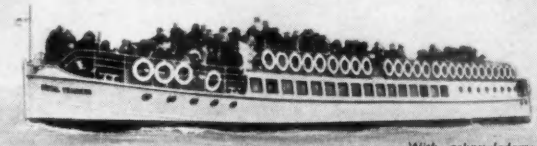

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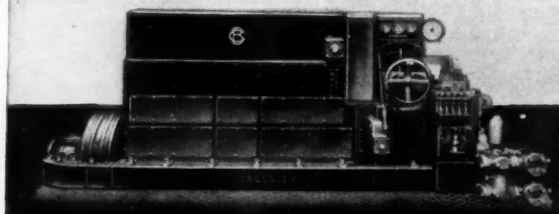

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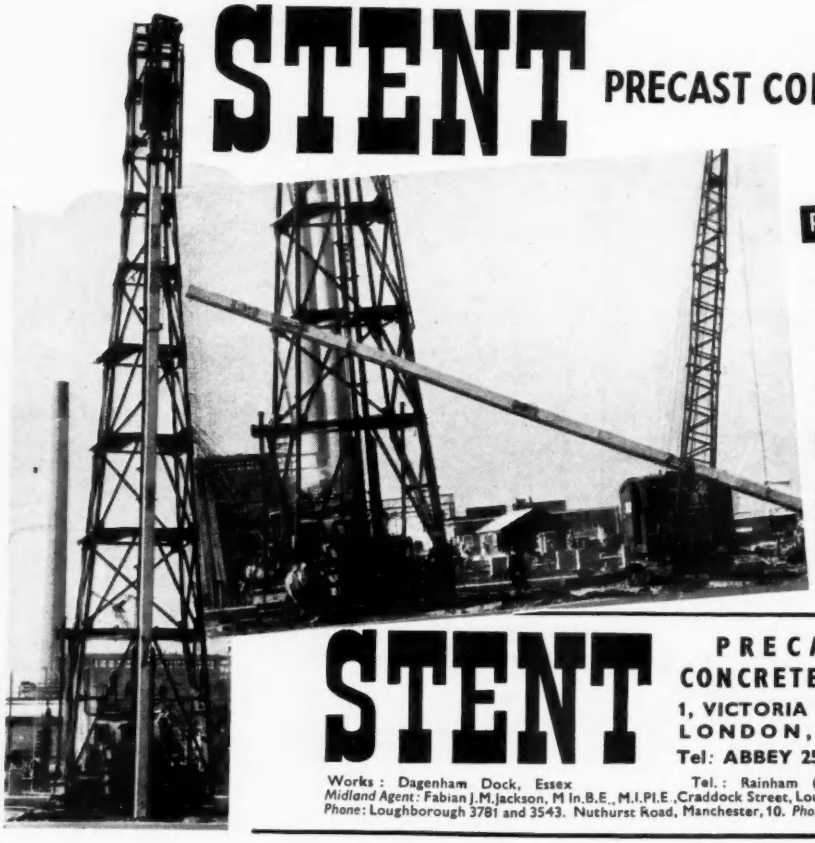

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